24. B. Tech in Electronics and Communication Engineering (with Specialization in BioMedical Engineering)

24. (a) Mission of the Department

Mission Stmt - 1	Build an educational process that is well suited to local needs as well as satisfies the national and international accreditation requirements
Mission Stmt - 2	Attract the qualified professionals and retain them by building an environment that foster work freedom and empowerment.
Mission Stmt - 3	With the right talent pool, create knowledge and disseminate, get involved in collaborative research with reputed institutes, and produce competent graduands.

24. (b) Program Educational Objectives (PEO)

The Program Educational Objectives for the Electronics and Communication Engineering (with Specialization in BioMedical Engineering) program describe accomplishments that graduates are expected to attain within five years after graduation. Graduates within 5 years of graduation will / should demonstrate:

PEO – 1	**Expertise** using their mathematical and scientific knowledge to solve emerging real-world problems, design and **create** novel products and solutions related to Medical Electronics and Instrumentation System Design that are technically sound, economically feasible and socially acceptable.
PEO – 2	Broad knowledge to **establish** themselves as **creative** practicing professionals, locally and globally, in fields such as design, research, testing and manufacturing of Medical Electronics and Instrumentation Systems.
PEO – 3	Communication skills (in both written and oral forms) and critical reasoning skills in **bridging** the divide between advanced technology and end users in the practice of BioMedical Engineering.
PEO – 4	Sustained **learning** and adapting to a constantly changing field through graduate work, professional development, self-study and collaborative activities.
PEO – 5	**Leadership** and initiative to ethically advance professional and organizational goals, facilitate the achievements of others, and obtain substantive results.
PEO – 6	Ability to work productively as individuals and in groups (**teamwork**) of diverse cultural and multidisciplinary backgrounds.

24. (c) Mission of the Department to Program Educational Objectives (PEO) Mapping

	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. - 3
PEO – 1	L	M	H
PEO – 2	H	L	H
PEO – 3	L	L	M
PEO – 4	M	L	M
PEO - 5	L	H	H
PEO – 6	H	H	H

H – High Correlation, M – Medium Correlation, L – Low Correlation

24. (d) Mapping Program Educational Objectives (PEO) to Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)														
	Graduate Attributes (GA)												Program Specific Outcomes (PSO)		
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
PEO - 1	H		H			H	M	H			H		H	M	
PEO - 2		H	M	H	M									H	
PEO - 3					L			M		H					M
PEO - 4												H	M		H
PEO - 5						L			M						L
PEO - 6						M			H						M

H – High Correlation, M – Medium Correlation, L – Low Correlation

Program Specific Outcomes (PSO)

Graduates of baccalaureate degree program in ECE with Specialization in BioMedical Engineering must demonstrate the ability to

PSO – 1	Apply scientific knowledge to solve problems at the interface of Engineering and Medicine.
PSO – 2	Design and develop medical devices in compliance with appropriate global standards.
PSO – 3	Promote multidisciplinary research to seek health care solutions.

24. (e) Program Structure for B.Tech in Electronics and Communication Engineering (with specialization in BioMedical Engineering)

1. Humanities & Social Sciences including Management Courses (H)

Course Code	Course Title	Hours/ Week L	T	P	C
18LEH101J	English	2	0	2	3
18LEH102J	Chinese				
18LEH103J	French				
18LEH104J	German	2	0	2	3
18LEH105J	Japanese				
18LEH106J	Korean				
18PDH101L	General Aptitude	0	0	2	1
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDH103J	Social Engineering	1	0	2	2
18PDH201L	Employability Skills & Practices	0	0	2	1
Total Learning Credits					**12**

2. Basic Science Courses (B)

Course Code	Course Title	Hours/ Week L	T	P	C
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18CYB101J	Chemistry	3	1	2	5
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18MAB201T	Transforms and Boundary Value Problems	3	1	0	4
18MAB203T	Probability and Stochastic Process	3	1	0	4
18MAB302T	Discrete Mathematics for Engineers	3	1	0	4
18BTB101T	Biology	2	0	0	2
Total Learning Credits					**32**

3. Engineering Science Courses (S)

Course Code	Course Title	Hours/ Week L	T	P	C
18MES101L	Engineering Graphics and Design	1	0	4	3
18EES101J	Basic Electrical and Electronics Engineering	3	1	2	5
18MES103L	Civil and Mechanical Engineering Workshop	1	0	4	3
18CSS101J	Programming for Problem Solving	3	0	4	5
18ECS201T	Control Systems	3	0	0	3
Total Learning Credits					**19**

4. Professional Core Courses (C)

Course Code	Course Title	Hours/ Week L	T	P	C
18ECC102J	Electronic Devices	3	0	2	4
18ECC103J	Digital Electronic Principles	3	0	2	4
18ECC104T	Signals and Systems	3	1	0	4
18ECC105T	Electromagnetics and Transmission Lines	3	0	0	3
18ECC201J	Analog Electronic Circuits	3	0	2	4
18ECC202J	Linear Integrated Circuits	3	0	2	4
18ECC203J	Microprocessor, Microcontroller and Interfacing Techniques	3	0	2	4
18ECC204J	Digital Signal Processing	3	0	2	4
18ECC205J	Analog and Digital Communication	3	0	2	4
18ECC206J	VLSI Design	3	0	2	4
18ECC301T	Wireless Communications	3	1	0	4
18ECC302J	Microwave & Optical Communications	3	0	2	4
18ECC303J	Computer Communication Networks	3	0	2	4
18ECC350T	Comprehension	0	1	0	1
Total Learning Credits					**52**

5. Professional Elective Courses (E)

Course Code	Course Title	Hours/ Week L	T	P	C
	Professional Elective – 1	3	0	0	3
	Professional Elective – 2	3	0	0	3
	Professional Elective – 3	3	0	0	3
	Professional Elective – 4	3	0	0	3
	Professional Elective – 5	3	0	0	3
	Professional Elective – 6	3	0	0	3
Total Learning Credits					**18**

6. Open Elective Courses (O)

Course Code	Course Title	Hours/ Week L	T	P	C
	Open Elective – 1	3	0	0	3
	Open Elective – 2	3	0	0	3
	Open Elective – 3	3	0	0	3
	Open Elective – 4	3	0	0	3
Total Learning Credits					**12**

7. Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)

Course Code	Course Title	Hours/ Week L	T	P	C
18ECP101L	Massive Open Online Course- I	0	0	2	1
18ECP102L	Industrial Training - I				
18ECP103L	Seminar – I				
18ECP104L	Massive Open Online Course- II	0	0	2	1
18ECP105L	Industrial Training - II				
18ECP106L	Seminar – II				
18ECP107L	Minor Project	0	0	6	3
18ECP108L	Internship (4-6 weeks)				
18ECP109L	Project	0	0	20	10
18ECP110L	Semester Internship				
Total Learning Credits					**15**

8. Mandatory Courses (M)

Course Code	Course Title	Hours/ Week L	T	P	C
18PDM101L	Professional Skills & Practices	0	0	2	0
18PDM201L	Competencies in Social Skills	0	0	2	0
18PDM202L	Critical & Creative Thinking Skills	0	0	2	0
18PDM301L	Analytical & Logical Thinking Skills	0	0	2	0
18LEM101T	Constitution of India	1	0	0	0
18LEM104J	Value Education	1	0	1	0
18GNM101L	Physical & Mental Health using Yoga	0	0	2	0
18GNM102L	NCC / NSS / NSO	0	0	2	0
18LEM109T	Indian Traditional Knowledge	1	0	0	0
18LEM110L	Indian Art Form	0	0	2	0
18CYM101T	Environmental Science	1	0	0	0
Total Learning Credits					**0**

List of Professional Elective Courses (E)

Course Code	Course Title	Hours/ Week L	T	P	C
18ECE260J	Biomedical Instrumentation	2	0	2	3
18ECE261T	Medical Imaging Techniques	3	0	0	3
18ECE262T	Biomaterials and Artificial Organs	3	0	0	3
18ECE263T	Biosensors	3	0	0	3
18ECE264T	Diagnostic and Therapeutic Equipment	3	0	0	3
18ECE265J	Biomedical Signal Processing	2	0	2	3
18ECE266T	BioMEMS	3	0	0	3
18ECE267J	Biomechanics	2	0	2	3
18ECE360T	Rehabilitation Engineering	3	0	0	3
18ECE361T	Biomedical Nanotechnology	3	0	0	3
18ECE362T	Physiological Modelling and Simulation	3	0	0	3
18ECE363J	Medical Image Processing	2	0	2	3
18ECE364T	Body Area Networks and Mobile Health Care	3	0	0	3
18ECE365T	Bio-inspired Human Machine Interface	3	0	0	3
18ECE366T	Implantable Bioelectronics	3	0	0	3
18ECE367T	Trouble Shooting and Regulatory Affairs in Medical Instruments	3	0	0	3
18ECE368T	Biomedical Laser Instruments	3	0	0	3
18ECE369T	Home Medicare Technology	3	0	0	3
18ECE460T	Acoustics and Optical Imaging	3	0	0	3
18ECE461T	Machine vision in Medical Technology	3	0	0	3

List of Open Elective Courses (O)
Any 4 Courses

Course Code	Course Title	Hours/ Week L	T	P	C
18ECO101T	Short-Range Wireless Communication	3	0	0	3
18ECO102J	Electronic Circuits & Systems	2	0	2	3
18ECO103T	Modern Wireless Communication Systems	3	0	0	3
18ECO104J	Audio and Speech Processing	2	0	2	3
18ECO105T	Underwater Acoustics	3	0	0	3
18ECO106J	PCB Design and Manufacturing	2	0	2	3
18ECO107T	Fiber Optics and Optoelectronics	3	0	0	3
18ECO108J	Embedded System Design using Arduino	2	0	2	3
18ECO109J	Embedded System Design using Raspberry Pi	2	0	2	3
18ECO110J	3D Printing Hardware and Software	2	0	2	3
18ECO131J	Virtual Instrumentation	2	0	2	3
18ECO132T	Analytical Instrumentation	3	0	0	3
18ECO133T	Logic and Distributed Control System	3	0	0	3
18ECO121T	Basics of Biomedical Engineering	3	0	0	3
18ECO122T	Hospital Information Systems	3	0	0	3
18ECO123T	Biomedical Imaging	3	0	0	3
18ECO124T	Human Assist Devices	3	0	0	3
18ECO125T	Quality Control for Biomedical Devices	3	0	0	3
18ECO126T	Sports Biomechanics	3	0	0	3

24. (f) Program Articulation for B.Tech in Electronics and Communication Engineering (with specialization in BioMedical Engineering)

Course Code	Course Name	Program Learning Outcomes (PLO)														
		Graduate Attributes												PSO		
		Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	Scientific knowledge	Design and develop medical devices	Multidisciplinary Research
18ECS101J	Basic Electrical Engineering and Circuit Theory	H	M	H	M	L								M	L	
18ECS102J	Electronics Design Workshop	M			H	H							L	M	L	
18ECS201T	Control Systems	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
18ECC102J	Electronic Devices	H		-	-	H	-	-	L	H	M	-	M	L	L	-
18ECC103J	Digital Electronic Principles	H	M	H	-	H	-	-	-	H	-	-	-	M	-	L
18ECC104T	Signals and Systems	H	H	M	M	M	-	-	-	-	-	-	-	L	-	L
18ECC105T	Electromagnetics and Transmission Lines	M	H	-	-		-	-	-	-	-	-	L		-	M
18ECC201J	Analog Electronic Circuits	L	M	H	-	M	-	-	-	M	-	-	M	H	L	
18ECC202J	Linear Integrated Circuits	H	M	H	-	M	-	-	-	M	-	-	-	H	L	H
18ECC203J	Microprocessor, Microcontroller and Interfacing Techniques	M	M	M	-	H	-	-	-	-	H	-	H	L	-	M
18ECC204J	Digital Signal Processing	H	M	H	-	-	-	-	-	-	-	-	-	M	-	H
18ECC205J	Analog and Digital Communication	M	H	H	M	H	-	-	-	H	H	-	M	H	M	H
18ECC206J	VLSI Design	H	M	M	-	H	-	-	-	H	M	L	M	-	-	M
18ECC301T	Wireless Communications	H	H	H	H	M	-	-	-	-	M	-	M	M	-	H
18ECC302J	Fundamentals of Microwave & Optical Communication	H	H	H	M	-	-	-	-	-	-	-	-	M	-	M
18ECC303J	Computer Communication Networks	-	-	M	-	L	L	M	-	-	-	-	M	-	-	H
18ECC350T	Comprehension	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
18ECE260J	Biomedical Instrumentation	M	M	-	-	-	-	-	-	-	-	-	-	M	-	-
18ECE261T	Medical Imaging Techniques	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
18ECE262T	Biomaterials and Artificial Organs	M	-	-	-	-	-	-	M	-	-	-	-	L	-	L
18ECE263T	Biosensors	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
18ECE264T	Diagnostic and Therapeutic Equipment	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
18ECE265J	Biomedical Signal Processing	M	-	M	-	M	-	-	-	L	L	M	-	M	-	L
18ECE266T	BioMEMS	M	-	M	-	-	-	-	-	-	-	-	-	M	-	-
18ECE267J	Biomechanics	M	M	M	M	M	-	-	-	-	-	-	L	L	L	M
18ECE360T	Rehabilitation Engineering	M	M	L	-	-	L	-	-	-	-	-	L	L	L	L
18ECE361T	Biomedical Nanotechnology	M	-	-	-	L	-	-	-	-	-	-	M	M	M	M
18ECE362T	Physiological Modelling and Simulation	M	M	L	-	-	-	-	-	-	-	-	-	M	-	-
18ECE363J	Medical Image Processing	M	-	M	-	M	-	-	-	L	L	M	-	M	-	L
18ECE364T	Body Area Networks and Mobile Health Care	L	-	L	-	-	-	-	-	-	-	-	-	L	-	M
18ECE365T	Bio-inspired Human Machine Interface	M	M	-	-	-	-	-	L	-	-	-	-	M	-	L
18ECE366T	Implantable Bioelectronics	M	-	-	-	L	L	-	-	-	-	-	-	M	L	-
18ECE367T	Trouble Shooting and Regulatory Affairs in Medical Instruments	M	M	M	-	-		-	-	-	-	-	M	M	L	-
18ECE368T	Biomedical Laser Instruments	M	M	-	-	-	-	-	M	-	-	-	-	M	M	-
18ECE369T	Home Medicare Technology	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
18ECE460T	Acoustics and Optical Imaging	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
18ECE461T	Machine vision in Medical Technology	M	M	L	L	M	-	-	-	-	-	-	M	L	-	L
18ECO121T	Basics of Biomedical Engineering	L	-	-	-	-	-	-	-	-	-	-	L	-	-	L
18ECO122T	Hospital Information Systems	M	-	-	-	-	M	M	L	L	-	-	L	L	L	L
18ECO123T	Biomedical Imaging	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
18ECO124T	Human Assist Devices	M	-	-	-	-	-	-	-	-	-	-	-	M	L	-
18ECO125T	Quality Control for Biomedical Devices	-	-	-	M	-	-	-	M	M	-	-	-	-	M	-
18ECO126T	Sports Biomechanics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18ECP101L/ 18ECP104L	Massive Open Online Course-I/II	-	-	-	-	-	M	L	-	-	H	-	H	-	M	-
18ECP102L/ 18ECP105L	Industrial Training-I/II	H	M	M	M	M	L	M	H	H	M	H	M	L	L	L
18ECP103L/ 18ECP106L	Seminar-I/II	-	M	M	H	-	M	H	-	-	H	-	M	-	-	-
18ECP107L/ 18ECP108L	Minor Project / Internship (4-6 weeks)	H	H	H	H	M	M	H	M	M	M	M	L	M	M	M
18ECP109L/ 18ECP110L	Project / Semester Internship	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

H – High Correlation, M – Medium Correlation, L – Low Correlation, PSO – Program Specific Outcomes (PSO)

24. (g) Implementation Plan for B. Tech in Electronics and Communication Engineering (with specialization in BioMedical Engineering)

Semester - I

Code	Course Title	Hours/ Week L	T	P	C
18LEH102J-18LEH106J	Foreign Language (Chinese/ French/ German/ Japanese / Korean)	2	0	2	3
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18CYB101J	Chemistry	3	1	2	5
18CSS101J	Programming for Problem Solving	3	0	4	5
18MES103L	Civil and Mechanical Engineering Workshop	1	0	4	3
18PDM101L	Professional Skills and Practices	0	0	2	0
18LEM102J	Value Education	1	0	1	0
18GNM102L	NCC / NSS / NSO	0	0	2	0
Total Learning Credits					20

Semester – II

Code	Course Title	Hours/ Week L	T	P	C
18LEH101J	English	2	0	2	3
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18MES101L	Engineering Graphics and Design	1	0	4	3
18EES101J	Basic Electrical and Electronics Engineering	3	1	2	5
18PDH101L	General Aptitude	0	0	2	1
18LEM101T	Constitution of India	1	0	0	0
18GNM101L	Physical and Mental Health using Yoga	0	0	2	0
Total Learning Credits					21

Semester - III

Code	Course Title	Hours/ Week L	T	P	C
18MAB201T	Transforms and Boundary Value Problems	3	1	0	4
18ECS201T	Control Systems	3	0	0	3
18ECC102J	Electronic Devices	3	0	2	4
18ECC103J	Digital Electronic Principles	3	0	2	4
18ECC104T	Signals and Systems	3	1	0	4
18ECC105T	Electromagnetics and Transmission Lines	3	0	0	3
18PDH103J	Social Engineering	1	0	2	2
18PDM201L	Competencies in Social Skills	0	0	2	0
18CYM101T	Environmental Science	1	0	0	0
Total Learning Credits					24

Semester - IV

Code	Course Title	Hours/ Week L	T	P	C
18MAB203T	Probability and Stochastic Process	3	1	0	4
18BTB101T	Biology	2	0	0	2
18ECC201J	Analog Electronic Circuits	3	0	2	4
18ECC202J	Linear Integrated Circuits	3	0	2	4
	Professional Elective-1	3	0	0	3
	Open Elective-1	3	0	0	3
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDM202L	Critical and Creative Thinking Skills	0	0	2	0
Total Learning Credits					22

Semester - V

Code	Course Title	Hours/ Week L	T	P	C
18MAB302T	Discrete Mathematics for Engineers	3	1	0	4
18ECC203J	Microprocessor, Microcontroller and Interfacing Techniques	3	0	2	4
18ECC204J	Digital Signal Processing	3	0	2	4
18ECC205J	Analog and Digital Communication	3	0	2	4
	Professional Elective – 2	3	0	0	3
	Open Elective – 2	3	0	0	3
18ECP101L/ 18ECP102L/ 18ECP103L	Massive Open Online Course-I / Industrial Training-I / Seminar-I	0	0	2	1
18PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
18LEM110L	Indian Art Form	0	0	2	0
Total Learning Credits					23

Semester - VI

Code	Course Title	Hours/ Week L	T	P	C
18ECC206J	VLSI Design	3	0	2	4
18ECC302J	Microwave and Optical Communications	3	0	2	4
18ECC303J	Computer Communication Networks	3	0	2	4
18ECC350T	Comprehension	0	1	0	1
	Professional Elective-3	3	0	0	3
	Professional Elective-4	3	0	0	3
	Open Elective-3	3	0	0	3
18ECP104L/ 18ECP105L/ 18ECP106L	Massive Open Online Course-II / Industrial Training-II / Seminar-II	0	0	2	1
18PDH201L	Employability Skills and Practices	0	0	2	1
18LEM109T	Indian Traditional Knowledge	1	0	0	0
Total Learning Credits					24

Semester - VII

Code	Course Title	Hours/ Week L	T	P	C
18ECC301T	Wireless Communications	3	1	0	4
	Professional Elective-5	3	0	0	3
	Professional Elective-6	3	0	0	3
	Open Elective-4	3	0	0	3
18ECP107L / 18ECP108L	Minor Project / Internship (4-6 weeks)	0	0	6	3
Total Learning Credits					16

Semester - VIII

Code	Course Title	Hours/ Week L	T	P	C
18ECP109L / 18ECP110L	Project / Semester Internship	0	0	20	10
Total Learning Credits					10

B. Tech in Electronics and Communication Engineering
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2018 Regulations

Engineering Science Courses (S)

Department of Electronics and Communication Engineering
SRM Institute of Science and Technology
SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECS201T	Course Name	CONTROL SYSTEMS	Course Category		Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MAB102T	Co-requisite Courses	18ECC104T	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Learn about mathematical modeling techniques of mechanical and electrical systems			
CLR-2 :	Impart knowledge about the transient and steady state error and analysis			
CLR-3 :	Identify and analyze stability of a system in time domain using root locus technique			
CLR-4 :	Know about different frequency domain analytical techniques			
CLR-5 :	Acquire the knowledge of a controller for specific applications			
CLR-6 :	Impart knowledge on controller tuning methods			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Determine Transfer function of a system by mathematical modeling, block diagram reduction and signal flow graphs	1,2	80	80
CLO-2 :	Identify the standard test inputs, time domain specifications and calculate steady state error	1,2	85	80
CLO-3 :	Plot a root locus curve and analyze the system stability using Routh array	2,3	90	85
CLO-4 :	Analyze the frequency domain specifications from bode and polar plots	2,3	90	85
CLO-5 :	Design a closed loop control system for specific application	1,2,3	80	80
CLO-6 :	Identification of controller parameters and tuning	1,2,3	85	85

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-5 :	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-6 :	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Open and closed loop control system	Standard test signals and their expression	Poles and zeros of a system	Frequency domain analysis	Controllers-Significance and Need
	SLO-2	Feedback and Feed forward control systems	Type number and order of a system	Pole zero plot and concept of s plane	Frequency domain specifications	Stability of closed loop systems
S-2	SLO-1	Transfer function of a system and basis of Laplace transforms	Transfer function of First order system for Step and ramp signal	Proper, Strictly Proper and Improper systems	Frequency domain plots, minimum and non minimum phase systems	SISO and MIMO control systems
	SLO-2	Need for mathematical modeling	Transfer function of First order system Impulse and parabolic signal	Characteristic equation	Correlation between time and frequency domain	Types of controllers-ON-OFF,P,I,D
S-3	SLO-1	Representation of mechanical translational systems using differential equation and determination of transfer function	General transfer function of second order system	Concept of stability from pole zero location	Bode plot approach and stability analysis	Composite Controller-PI,PD and PID
	SLO-2		Identification of damping factor and classification based on it	Need for Stability analysis and available techniques	Rules for sketching bode plot	Controller parameters and tuning methods
S-4	SLO-1	Representation of mechanical rotational systems and determination of transfer function	Step response of critically damped second order system	Necessary and sufficient Condition for stability	Bode plot of typical systems	Design Specification, controller configurations- ON-OFF controller
	SLO-2		Step response of under damped second order system	Significance of Routh Hurwitz Technique		
S-5	SLO-1	Conversions of Mechanical system to Electrical system	Step response of over damped second order system	Computation of Routh array	Bode plot of typical systems	Design Specification, controller configurations-PID controller
	SLO-2	f-V and f-I electrical analogies	Step response of undamped second order system	Routh array of stable systems		

S-6	**SLO-1**	*Block diagram reduction rules and methodology*	*Time domain specifications and their significance*	*Routh array of Unstable systems*	*Polar plot and significance*	*Design of speed control system for DC motor*
	SLO-2		*Numerical solution*	*Routh array of Unstable systems*	*Nyquist stability criterion*	
S-7	**SLO-1**	*Evaluation of transfer function using block diagram reduction*	*Transient and steady state error analysis*	*Root locus technique*	*Sketching of polar plot on polar graphs*	*Design of control system for Twin Rotor Multi input Multi output System(TRMS) with one degree of freedom*
	SLO-2		*Static and dynamic Error coefficients*	*Rules for sketching root locus*		
S-8	SLO-1	*Signal flow graphs and evaluation of transfer function*	*Static error constants and evaluation of steady state error*	*Root locus plot of typical systems*	*Polar plot of typical systems*	*Case study 1*
	SLO-2					
S-9	SLO-1	*Block diagram to signal flow conversion*	*Dynamic error constants and evaluation of steady state error*	*Root locus plot of typical systems*	*Polar plot of typical systems*	*Case study 2*
	SLO-2					

Learning Resources	*1.* Nagrath.J and Gopal.M,, "Control System Engineering", 5th Edition, New Age, 2007 2. Benjamin C Kuo, "Automatic Control System", 9th edition, John Wiley & Sons, 2010	3. Gopal.M, "Control System Principles and Design", 2nd Edition, TMH, 2002 4. Sivanandam and Deepa, "Control system Engineering using MATLAB", 2nd edition, Vikas publishers, 2007

Learning Assessment						
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)				Final Examination (50% weightage)
		CLA – 1 (10%)	CLA – 2 (15%)	CLA – 3 (15%)	CLA – 4 (10%)	
Level 1	Remember	*40%*	*30%*	*30%*	*30%*	*30%*
	Understand					
Level 2	Apply	*40%*	*40%*	*40%*	*40%*	*40%*
	Analyze					
Level 3	Evaluate	*20%*	*30%*	*30%*	*30%*	*30%*
	Create					
	Total	100 %	100 %	100 %	100 %	100 %

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Anuj Kumar, Bombardier* Transportation, Ahmedabad, *kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor* of ECE, CEG, Anna University, *meena68@annauniv.edu*	*Dr. T. Deepa, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*Mrs. R. Bakhya Lakshmi, SRMIST*

B. Tech in Electronics and Communication Engineering
(with Specialization in BioMedical Engineering)

2018 Regulations

Professional Core Courses (C)

Department of Electronics and Communication Engineering
SRM Institute of Science and Technology
SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECC102J	Course Name	ELECTRONIC DEVICES	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18EES101J	Co-requisite Courses	Nil	Progressive Courses	18ECC201J, 18ECC202J, 18ECE203T, 18ECE303T, 18ECE321T, 18ECE322T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Provide a basis for understanding semiconductor material, how a pn junction is formed and its principle of operation			
CLR-2 :	Explain the importance of diode in electronic circuits by presenting appropriate diode applications			
CLR-3 :	Discuss the basic characteristics of several other types of diodes that are designed for specific applications			
CLR-4 :	Describe the basic structure, operation and characteristics of BJT, and discuss its use as a switch and an amplifier.			
CLR-5 :	Describe the basic structure, operation and characteristics of MOSFET, and discuss its use as a switch and an amplifier.			
CLR-6 :	Use modern engineering tools such as PSPICE to carry out design experiments and gain experience with instruments and methods used by technicians and electronic engineers			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Explain the operation, characteristics, parameters and specifications of semiconductor diodes and special diodes	1	60	70
CLO-2 :	Illustrate important applications of semiconductor diodes and special diodes.	2	60	70
CLO-3 :	Review bipolar transistor construction, operation, characteristics and parameters, as well as its application in amplification and switching.	1	60	70
CLO-4 :	Review field-effect transistor construction, operation, characteristics and parameters, as well as its application in amplification and switching.	1	60	70
CLO-5 :	Construct a circuit, then make functional measurements to understand the operating characteristics of the device / circuit.	3	70	75
CLO-6 :	Solve specific design problem, which after completion will be verified using modern engineering tools such as PSPICE.	2	70	75

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	H	-	-	-	-	-	-	-	-	-	-	M	-	-	-
CLO-2 :	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-
CLO-3 :	H	-	-	-	-	-	-	-	-	-	-	M	-	-	-
CLO-4 :	H	-	-	-	-	-	-	-	-	-	-	M	-	L	-
CLO-5 :	-	-	-	-	H	-	-	-	-	-	-	-	L	L	-
CLO-6 :	-	-	-	-	H	-	-	L	H	M	-	M	-	-	-

Duration (hour)		Semiconductor Diodes	Diode Circuits	Special Diodes	Bipolar Junction Transistors	MOS Field-Effect Transistors
		15	15	15	15	15
S-1	SLO-1	Basic semiconductor theory: Intrinsic & extrinsic semiconductors	HWR operation, Efficiency and ripple factor	Backward diode	Physical structure	Physical structure
	SLO-2	Current flow in semiconductors	Problem solving	Varactor diode	Device operation of BJT	Device operation of E-MOSFET & D-MOSFET
S-2	SLO-1	PN junction theory: Equilibrium PN junction	Center-Tapped Transformer FWR operation, Efficiency and ripple factor	Step recovery diode	Current-Voltage characteristics of CE BJT configuration	I-V characteristics of E-MOSFET
	SLO-2	Forward biased PN junction	Problem solving	Point-contact diode	Current-Voltage characteristics of CE BJT configuration	Problem solving
S-3	SLO-1	Reverse biased PN junction	Bridge FWR operation, Efficiency and ripple factor	Metal-semiconductor junction: Structure, Energy band diagram	Current-Voltage characteristics of CB BJT configuration	Derive drain current
	SLO-2	Relation between Current and Voltage	Problem solving	Forward & Reverse Characteristics of Schottky Diode	Current-Voltage characteristics of CB BJT configuration	Problem solving
S 4-5	SLO-1 / SLO-2	Lab 1: PN Junction Diode Characteristics	Lab 4: Diode clipping and clamping circuits	Lab 7: Series and Shunt Regulators	Lab 10: BJT and MOSFET Switching Circuits	Lab 13: Repeat Experiments
S-6	SLO-1	Calculate depletion width	Filters: Inductor & Capacitor Filters	Tunnel Diode	Current-Voltage characteristics of CC BJT configuration	Derive transconductance
	SLO-2	Calculate barrier potential	Problem solving	Tunnel Diode	Current-Voltage characteristics of CC BJT configuration	Problem solving
S-7	SLO-1	Derive diode current equation	Filters: LC & CLC Filters	Gunn Diode	BJT as an amplifier	CMOS FET

	SLO-2	*Derive diode current equation*	*Problem solving*	*Gunn Diode*	*BJT as a switch*	*MOSFET as an amplifier*
S-8	SLO-1	*Effect of Capacitance in PN junction: Transition Capacitance*	*Diode Clippers*	*IMPATT Diode*	*BJT circuit models – h-parameter*	*MOSFET as a switch*
	SLO-2	*Diffusion Capacitance*	*Problem solving*	*IMPATT Diode*	*BJT circuit models – hybrid-π parameter*	*Problem solving*
S 9-10	SLO-1 SLO-2	*Lab 2: Zener diode characteristics*	*Lab 5: BJT Characteristics*	*Lab 8: MOSFET Characteristics*	*Lab 11: Photoconductive Cell, LED, and Solar Cell Characteristics*	*Lab-14: Model Examination*
S-11	SLO-1	*Energy band structure of PN Junction Diode*	*Diode Clampers*	*PIN Diode*	*BJT biasing circuits and stability analysis: Base bias and emitter bias*	*Biasing Circuits for MOSFET: Gate Bias*
	SLO-2	*Ideal diode and its current-voltage characteristics*	*Problem solving*	*PIN Photodiode*	*Problem solving*	*Problem Solving*
S-12	SLO-1	*Terminal characteristics & parameters*	*Voltage Multipliers*	*Avalanche photodiode*	*Voltage-divider bias*	*Self-bias*
	SLO-2	*Diode modeling*	*Zener diode: Characteristics, breakdown mechanisms*	*Laser diode*	*Problem solving*	*Problem Solving*
S-13	SLO-1	*DC load line and analysis*	*Zener resistances and temperature effects Zener diode as voltage regulator*	*Problem solving*	*Collector-feedback bias*	*Voltage-divider bias*
	SLO-2	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem Solving*
S 14-15	SLO-1 SLO-2	*Lab 3: Diode rectifier circuits*	*Lab 6: BJT Biasing Circuits*	*Lab 9: MOSFET Biasing Circuits*	*Lab 12: Simulation experiments using PSPICE*	*Lab 15: End-Semester Practical Examination*

Learning Resources	*1. David A. Bell, Electronic Devices and Circuits, 5th ed., Oxford University Press, 2015* *2. Donald Neamen, Electronic Circuits: Analysis and Design, 3rd ed., McGraw-Hill Education, 2011* *3. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits: Theory and Applications, OUP, 2014* *4. Thomas L. Floyd, Electronic Devices", 9th ed., Pearson Education, 2013*	*5. Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 11th ed., Pearson Education, 2013* *6. Muhammad Rashid, Microelectronic Circuits: Analysis & Design, 2nd ed., Cengage Learning, 2010* *7. Muhammed H Rashid, Introduction to Pspice using OrCAD for circuits and electronics, 3rd ed., Pearson, 2004* *8. Laboratory Manual, Department of ECE, SRM University*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr. Hariharasudhan – Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. Diwakar R Marur, SRMIST*

Course Code	18ECC103J	Course Name	DIGITAL ELECTRONIC PRINCIPLES	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18EES101J	Co-requisite Courses	Nil	Progressive Courses	18ECC203J, 18ECC206J, 18ECE206J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand binary codes, digital arithmetic operations and able to simplify Boolean logic expressions
CLR-2 :	Describe how basic TTL and CMOS gates operate at the component level
CLR-3 :	Able to design simple combinational logics using basic gates and MSI circuits
CLR-4 :	Familiarize with basic sequential logic components: flip-flops, registers, counters and their usage, and able to design and analyze sequential logic circuits and Finite State Machines.
CLR-5 :	Know how to implement logic circuits using PLDs.
CLR-6 :	Use modern engineering tools such as PSPICE / Logisim to carry out design experiments and gain experience with instruments and methods used by technicians and electronic engineers

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Simplify Boolean expressions; carry out arithmetic operations with binary numbers; apply parity method for error detection and correction.	1	90	75	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Explain the operational characteristics / properties of digital ICs; implement gates as well as other types of IC devices using two major IC technologies, TTL and CMOS.	1	80	70	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Identify eight basic types of fixed-function combinational logic functions and demonstrate how the devices / circuits can be used in building complete digital systems such as computers.	2,3	90	75	-	M	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Analyze and design Mealy and Moore models of sequential circuits using several types of flip-flops.	2,3	90	75	-	M	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Implement multiple output combinational logic circuits using PLDs; Explain the operation of a CPLD and FPGA.	2	80	75	-	M	H	-	L	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Solve specific design problem, which after completion will be verified using modern engineering tools such as PSPICE / Logisim	2	90	75	-	M	H	-	H	-	-	-	H	-	-	-	M	-	L

Duration (hour)		Binary Codes, Digital Arithmetic and Simplification of Boolean Functions	Logic Families	Combinational Systems	Sequential Systems	Memory and Programmable Logic
		15	15	15	15	15
S-1	SLO-1	Binary Codes, Digital Arithmetic and Simplification of Boolean Functions	Introduction	Binary arithmetic units	Flip-flop and Latch: SR latch,	RAM Memory decoding
	SLO-2	Error detecting codes	TTL Logic Family	Adder	JK flip-flop, T flip-flop, D flip-flop	ROM
S-2	SLO-1	Error correcting code	Totem-pole TTL	Design of Half adder	Master-slave RS flip-flop	Programmable Logic Devices (PLDs): Basic concepts
	SLO-2	Hamming Code	open-collector and tristate TTL	Design of Full adder	Master-slave JK flip-flop	PROM
S-3	SLO-1	Arithmetic number representation	Schottkey TTL, standard TTL characteristics	Subtractor	Registers & Counters	PROM as PLD
	SLO-2	Binary arithmetic	Metal Oxide Semiconductor logic families	Design subtractor using logic gates	Shift registers (SISO, SIPO, PISO, PIPO)	Programmable Array Logic (PAL)
S 4-5	SLO-1 SLO-2	LAB 1: Study of logic gates	LAB 4: Design and implement encoder and decoder using logic gates	LAB 7: Implement combinational logic functions using standard ICs	LAB 10: Design and implement Synchronous Counters	LAB 13: Construct combinational circuit using Logisim
S-6	SLO-1	Hexadecimal arithmetic	N-MOS	n-bit parallel adder & subtractor	Universal shift register	Programmable Array Logic (PAL)

	SLO-2	*Hexadecimal arithmetic*	*P-MOS*	*look ahead carry generator*	*Counters: Asynchronous/Ripple counters*	*Programmable Logic Array (PLA)*
S-7	SLO-1	*BCD arithmetic simplification*	*CMOS logic circuits*	*Decoder*	*Synchronous counters, Modulus-n Counter*	*Programmable Logic Array (PLA)*
	SLO-2	*Minimization of Boolean Functions: Algebraic simplification*	*Characteristics of MOS logic*	*Encoder*	*Ring counter, Johnson counter*	*Design combinational circuits using PLD's*
S-8	SLO-1	*Problems on Algebraic simplification*	*Compare MOS logic circuits(CMOS) with TTL digital circuit*	*Multiplexer*	*Up-Down counter*	*Design combinational circuits using PLD's*
	SLO-2	*Karnaugh map simplification*	*Electrical characteristics*	*Demultiplexer*	*Mealy and Moore model*	*Design combinational circuits using PLD's*
S 9-10	SLO-1 SLO-2	*LAB 2: Design and implement Adder and Subtractor using logic gates*	*LAB 5: Design and implement Multiplexer and Demultiplexer using logic gates*	*LAB 8: Verify characteristic table of flip-flops*	*LAB 11: Construct and verify shift registers*	*LAB 14: Model Practical Examination*
S-11	SLO-1	*Problems on Karnaugh map simplification*	*Fan-out*	*Code converters*	*Synchronous (Clocked) sequential circuits*	*Design of combinational circuits using PLD's*
	SLO-2	*Problems on Karnaugh map simplification*	*Propagation Delay*	*Magnitude comparators*	*Synchronous (Clocked) sequential circuits*	*Design sequential circuits using PLD's*
S-12	SLO-1	*Quine McCluskey*	*Power dissipation*	*Magnitude comparators*	*Synchronous (Clocked) sequential circuits*	*Design sequential circuits using PLD's*
	SLO-2	*Tabulation method*	*Noise margin*	*Parity generators (Odd parity)*	*Analyze and design synchronous sequential circuits*	*Design sequential circuits using PLD's*
S-13	SLO-1	*Problems on Quine McCluskey or Tabulation method.*	*Supply voltage levels*	*Parity generators (Even parity)*	*State reduction*	*Design sequential circuits using PLD's*
	SLO-2	*Exercise problems using Tabulation method*	*Operational voltage levels*	*Implementation of combinational logic by standard IC's.*	*State assignment*	*Design sequential circuits using PLD's*
S 14-15	SLO-1 SLO-2	*Lab 3: Design and Implement 2-bit Magnitude Comparator using logic gates*	*LAB-6: Design and implement code converters using logic gates*	*LAB 9: Construct and verify 4-bit ripple counter, Mod-10/Mod-12 ripple counters*	*Lab 12: Construct mini project work*	*LAB 15: University Practical Exam*

Learning Resources	1. *Morris Mano M, Michael D. Ciletti, Digital Design with an Introduction to the Verilog HDL, 5th ed., Pearson Education, 2014* 2. *Charles H Roth (Jr), Larry L. Kinney, Fundamentals of Logic Design, 5th ed., Cengage Learning India Edition, 2010* 3. *Thomas L. Floyd, Digital Fundamentals, 10th ed., Pearson Education, 2013*	4. *Ronald J. Tocci, Digital System Principles and Applications, 10th ed., Pearson Education, 2009* 5. *Donald P Leach, Albert Paul Malvino, Goutam Saha, Digital Principles and Applications, 6th ed., Tata-Mcgraw Hill, 2008* 6. *LAB MANUAL, Department of ECE, SRM University*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
r. Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECC104T	Course Name	SIGNALS AND SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	18MAB201T	Progressive Courses	18ECC204J, 18ECS201T, 18ECE240T, 18ECE241J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Know about requirements of signal and system analysis in communication.			
CLR-2 :	Understand the analysis of Periodic and Aperiodic Continuous time Signals using Fourier series and transforms			
CLR-3 :	Educate about Continuous time system through Laplace transform and Convolution integral			
CLR-4 :	Understand the characterization of the Discrete time signals and system through DTFT, Convolution sum			
CLR-5 :	Understand the concept of Z-Transform for the analysis of DT system			
CLR-6 :	Develop expertise in time-domain and frequency domain approaches to the analysis of continuous and discrete systems and also the ability to apply modern computation software tool for the analysis of electrical engineering problems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Understand the various classifications of Signals and Systems	1	65	60	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Analyze Periodic and Aperiodic Continuous time Signals using Fourier series and Fourier Transform	2	65	60	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Analyze and characterize the Continuous time system through Laplace transform and Convolution integral.	2	65	60	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Analyze and characterize the Discrete time signals and system through DTFT, Convolution sum	2	65	60	-	H	M	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Analyze and characterize the Discrete time system using Z transform	2	65	60	-	H	M	-	-	-	-	-	-	-	-	-	-	-	L
CLO-6 :	Apply the mathematical techniques used for continuous-time signal and discrete-time signal and system analysis	2	65	60	-	H	-	M	M	-	-	-	-	-	-	-	L	-	-

Duration (hour)		Classification of Signals and Systems	Analysis of Continuous Time Signals	Analysis of LTI CT System	Analysis of DT Signals and Systems	Analysis of LTI DT System using Z-Transform
		12	12	12	12	12
S-1	SLO-1	Introduction to signals and systems	Introduction to Fourier series	System modeling	Representation of sequences	Z transform – introduction
	SLO-2	Requirements of signal and system analysis in communication	Representation of Continuous time Periodic signals	Description of differential equations	Discrete frequency spectrum and range	Region of convergence of finite duration sequences
S-2	SLO-1	Continuous time signals (CT signals)	Fourier series: Trigonometric representation	Solution of Differential equation	Discrete Time Fourier Transform (DTFT) – Existence	Properties of ROC
	SLO-2	Discrete time signals (DT signals)	Fourier series: Trigonometric representation	Differential equation: Zero initial conditions	DTFT of standard signals	Properties of ROC
S-3	SLO-1	Representation of signals: Step, Ramp, Pulse, Impulse	Fourier series: Cosine representation	Differential equation: Zero state response	Properties of DTFT	Properties of Z transform
	SLO-2	Representation of signals: Sinusoidal, Exponential	Fourier series: Cosine representation	Differential equation: Zero Input response	Properties of DTFT	Properties of Z transform
S-4	SLO-1	Basic operation on the signals	Symmetry conditions	Total Response	Inverse DTFT	Unilateral z transforms
	SLO-2	Problems on signal operations	Properties of Continuous time Fourier series	Step response	Practice on IDTFT	Properties of z transform
S-5	SLO-1	Classification of CT and DT signals: Periodic & Aperiodic signals.	Practice problems on Fourier series	Impulse response	Impulse response of a system with DTFT	Bilateral Z transforms
	SLO-2	Classification of CT and DT signals: Deterministic & Random signals.	Practice problems on Fourier series	Frequency response	Frequency response of a system with DTFT	Properties of z transform

S-6	SLO-1	*Energy signal*	*Gibb's Phenomenon*	*Convolution integral*	*Practice problems*	*Relation between DTFT and Z transform*
	SLO-2	*Power signal*	*Parseval's relation for power signals*	*Properties of convolution*	*Practice problems*	*Practice problems*
S-7	SLO-1	*Even & Odd signals*	*Power density spectrum,*	*Practice Problems*	*Solution of linear constant coefficient difference equations*	*condition for causality in Z domain*
	SLO-2	*Even & Odd signals*	*Frequency spectrum.*	*Practice Problems*	*Initial conditions*	*condition for stability in Z domain*
S-8	SLO-1	*CT systems and DT systems*	*Fourier transform: Introduction*	*Signal and system analysis with Laplace transform*	*Solution of difference equations*	*Inverse Z transform*
	SLO-2	*Classification of systems: Static & Dynamic*	*Representation of Continuous time signals*	*Convergence of Laplace Transform*	*Zero input response*	*Power series expansion*
S-9	SLO-1	*Superposition theorem*	*Properties of Continuous time Fourier transform*	*Properties of Laplace transform*	*Solution of difference equations with Zero state response*	*Inverse Z transform with Partial fraction*
	SLO-2	*Linear & Nonlinear system*	*Properties of Continuous time Fourier transform*	*Properties of Laplace transform*	*Total response*	*Inverse Z transform with Partial fraction*
S-10	SLO-1	*Time-variant & Time-invariant system*	*Parseval's relation for energy signals*	*Inverse Laplace transform*	*Evaluation of Impulse response*	*Residue method*
	SLO-2	*Time-invariant system*	*Energy density spectrum*	*Problems*	*Evaluation of Step response*	*Convolution method*
S-11	SLO-1	*Causal system*	*Analysis of LTI system using Fourier Transform*	*Analysis and characterization of LTI system using Laplace transform*	*Convolution Properties*	*Analysis and characterization of DT system using Z-transform*
	SLO-2	*Noncausal system*	*Analysis of LTI system using Fourier Transform*	*Analysis and characterization of LTI system using Laplace transform*	*Convolution Sum*	*Analysis and characterization of DT system using Z-transform*
S-12	SLO-1	*Stable & Unstable,LTI System*	*Practice problems on Fourier Transform*	*Practice problems on Laplace transform*	*Circular convolution*	*Practice problems on LTI-DT systems in Z transform*
	SLO-2	*Unstable, LTI System*	*Practice problems on Fourier Transform*	*Practice problems on Laplace transform*	*Frequency response*	*Practice problems on LTI-DT systems in Z transform*

Learning Resources	1. *Alan V Oppenheim, Ronald W. Schafer Signals & Systems, 2nd ed., Pearson Education, 2015* 2. *P.Ramakrishna Rao, Shankar Prakriya, Signals & Systems, 2nd ed., McGraw Hill Education, 2015* 3. *Simon Haykin, Barry Van Veen, Signals and Systems, 2nd ed., John Wiley & Sons Inc., 2007* 4. *Lathi B.P, Linear Systems & Signals, 2nd ed., Oxford Press, 2009*	5. *John G. Proakis, Manolakis, Digital Signal Processing, Principles, Algorithms and Applications, 4th ed., Pearson Education, 2007.* 6. *Software: Matlab Student Version Release 2011a, Mathworks, Inc. The Matlab Student Version and toolboxes may be purchased through the Mathworks website at http://www.mathworks.com/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. A. Ruhan Bevi, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. D. Malathi, SRMIST*

Course Code	18ECC105T	Course Name	ELECTROMAGNETICS AND TRANSMISSION LINES	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18PYB101J	Co-requisite Courses	Nil	Progressive Courses	18ECC301T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Clark's Table, IS : 456-2000	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Gain knowledge on the basic concepts and insights of Electric field
CLR-2 :	Gain knowledge on the basic concepts and insights of Magnetic field and Emphasize the significance of Maxwell's equations.
CLR-3 :	Interpret the wave propagation in guided waveguide.
CLR-4 :	Acquire the fundamental knowledge on Transmission Line Theory.
CLR-5 :	Acquire the knowledge on transmission line parameter calculation and impedance matching concepts.
CLR-6 :	Acquire knowledge on theoretical concepts and analysis techniques to find solutions for problems related to electromagnetic wave propagation and Transmission line Theory.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO-1 : Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Apply the concepts and knowledge to solve problems related to electric field.	2	60	60	M	H	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-2 :	Analyze the concepts of Magnetic field and Maxwell's equations in the real world application.	2	60	60	H	M	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-3 :	Translate the phenomenon of guided wave propagation and its mode of propagation.	1	60	60	H	M	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-4 :	Describe the importance of transmission line theory applicable to low frequency transmission lines.	1	60	60	M	H	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-5 :	Solve transmission line parameter and impedance matching through analytical and graphical methods.	2	60	60	M	H	-	-	-	-	-	-	-	-	-	-	-	-	M
CLO-6 :	Demonstrate how electromagnetic waves are generated using Maxwell's equations and how Transmission lines are used to transfer electromagnetic energy from one point to another with minimum losses over a wideband of frequencies.	2	60	60	M	H	-	-	-	-	-	-	-	-	-	L	-	-	H

Duration (hour)		Electrostatics	Magnetostatics and Maxwells Equations	Electromagnetic Waves and Waveguides	Transmission Line Theory	Transmission Line Calculator and Impedance Matching
		9	9	9	9	9
S-1	SLO-1	Introduction	Energy density in electrostatic field	Introduction	Transmission line parameters	Introduction
	SLO-2	Rectangular co-ordinate	Problem discussion.	Waves in general	Transmission line parameters	Smith chart Introduction
S-2	SLO-1	Cylindrical & Spherical Co-ordinate	Biot savart law-Magnetic field intensity due to Infinite line charge	Plane wave in lossless dielectric	Transmission line equivalent circuit	Reflection coefficient, Standing wave ratio Input impedance calculation in smith chart
	SLO-2	Review of vector calculus	H- due finite and semi finite line charge	Plane wave in free space	Explanation	Practice problems.
S-3	SLO-1	Coulomb's Law and field intensity	Ampere's circuital law& application: Infinite line current	Plane wave in good conductor	Transmission line equation derivation	Single stub matching Introduction
	SLO-2	Problem based on coulomb's law	Infinite Sheet current	Problems based on plane waves in lossless, free space and good conductor	Problem discussion.	Procedure for single stub matching
S-4	SLO-1	Electric field due to continuous charge distribution-.Concept	Infinitely long coaxial Transmission line	Rectangular waveguide	Transmission line characteristics: lossless line	Problems solving in smith chart
	SLO-2	Derivation of E due Infinite Line charge	Problem based on ACL.	Rectangular waveguide-Problems	Distortionless line.	Problems solving in smith chart
S-5	SLO-1	Electric field due to sheet charge	Magnetic flux density	Transverse Electric (TE) mode	Input impedance derivation	Impedance matching using Quarter wave transformer

	SLO-2	*Problem based on sheet charge*	*Problem based on magnetic field and flux.*	*Transverse Electric (TE) mode-problems*	*Problems for input impedance calculation.*	*Problems.*
S-6	SLO-1	*Electric field due to volume charge*	*Maxwell's equation for static field*	*Transverse Electric (TE) mode*	*Standing wave ratio*	*Single stub tuner*
	SLO-2	*Electric flux density*	*Faraday's law*	*Transverse Electric (TE) mode-Problems*	*Calculation of standing wave ratio.*	*Problem discussion*
S-7	SLO-1	*Gauss law application-point charge*	*Transformer EMF*	*Wave propagation in guide*	*Reflection coefficient*	*Slotted Line (Impedance Measurement)*
	SLO-2	*Electric flux due infinite line charge*	*Motional EMF*	*Problem discussion*	*Problem discussion.*	*Problem discussion*
S-8	SLO-1	*Electric flux due sheet charge*	*Displacement current.*	*Power Transmission*	*Shorted line, open circuited line*	*Transmission Lines as circuit Elements*
	SLO-2	*Electric flux due coaxial cable*	*Maxwell's equation in time varying field*	*Calculation of Pavg and Ptotal*	*Matched line*	*Problem discussion*
S-9	SLO-1	*Relation between E&V*	*Time varying potential concepts*	*Power attenuation*	*Power calculations*	*Additional smith chart problem solving.*
	SLO-2	*Electric dipole and flux lines*	*Time varying potential derivation.*	*Calculation of αTE and αTE*	*Problem discussion.*	*Additional smith chart problem solving.*

Learning Resources	1. *Matthew N. O. Sadiku., S. V. Kulkarni, Elements of Electromagnetics, 6th ed., Oxford University Press, 2015* 2. *G. S. N. Raju, Electromagnetic Field Theory and Transmission Lines, Pearson Education, 2006* 3. *Nannapaneni Narayana Rao, Principles of Engineering Electromagnetics,6th ed., Pearson Education, 2016*	4. *William H. Hayt,Jr., John A.Buck., Engineering Electromagnetics, 8th ed., Tata McGraw-Hill 2012* 5. *John D.Ryder, Networks, Lines and Fields, PHI, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.aniii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. P. Eswaran, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECC201J	Course Name	ANALOG ELECTRONIC CIRCUITS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC102J	Co-requisite Courses	18ECC202J	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the operation and design of BJT amplifier circuits for a given specification
CLR-2 :	Understand the operation and design of MOSFET amplifier circuits for a given specification
CLR-3 :	Understand the effects of negative feedback on amplifier circuits, and analyze the different RC and LC oscillator circuits to determine the frequency of oscillation
CLR-4 :	Understand the operation and design of various types of power amplifier circuits.
CLR-5 :	Understand how matched transistor characteristics are used in the IC design and to be able to design BJT and MOSFET current sources.
CLR-6 :	Gain hands-on experience to put theoretical concepts learned in the course to practice.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 (Level of Thinking (Bloom))	Learning 2 (Expected Proficiency (%))	Learning 3 (Expected Attainment (%))	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO 1 Professional Achievement	PSO 2 Project Management Techniques	PSO 3 Analyze & Research
CLO-1 :	Analyze and design bipolar amplifier circuits to meet certain specifications, and to Analyze the frequency response of amplifier circuits, taking into account various circuit capacitors, to determine the bandwidth of the circuit.	2,3	70	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Analyze and design MOSFET amplifier circuits to meet certain specifications, and to Analyze the frequency response of amplifier circuits, taking into account various circuit capacitors, to determine the bandwidth of the circuit.	2,3	70	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Understand the characteristics and principles of feedback amplifier circuits and oscillator circuits to analyze and design circuits to meet certain specifications.	2,3	70	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Analyze three principle classes of power amplifiers, and determine the maximum possible conversion efficiency of each type of power amplifier	2,3	70	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Design the basic circuit building blocks that are used in the design of IC amplifiers, namely current mirrors and sources	2,3	70	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Analyze and design analog electronic circuits using discrete components, and take measurement of various analog circuits to compare experimental results in the laboratory with theoretical analysis.	3	90	80	-	-	H	-	M	-	-	-	M	-	-	M	H	L	-

Duration (hour)		BJT Amplifiers	FET Amplifiers	Feedback amplifies & Oscillators	Oscillators & Power Amplifiers	IC Biasing & Amplifiers with Active Load
		15	15	15	15	15
S-1	SLO-1	Overview of DC analysis of BJT circuits	Overview of FET DC circuit analysis	Basic feedback concepts, general feedback structure	Crystal Oscillators	BJT current sources: Cascode current source, Widlar current source
	SLO-2	Overview of BJT models	Problem solving	Properties of negative feedback	Problem solving	Multi-transistor current source Problem solving
S-2	SLO-1	AC load line analysis	Graphical analysis, load lines, and small-signal models	Feedback Topologies: Voltage-Series & Current-Series feedback connections	Negative-resistance oscillator	FET current sources: 2-transistor MOSFET current source
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
S-3	SLO-1	AC analysis of Common-Emitter BJT amplifier config. using hybrid-π model	AC analysis of Common-Source MOSFET amplifier configuration	Feedback Topologies: Voltage-Shunt & Current-Shunt feedback connections	Power Amplifiers: Definitions and amplifier types	FET current sources: Cascode current mirror and Wilson current mirror
	SLO-2	Problem solving	Problem solving	Problem solving	Q point placement	Problem solving
S 4-5	SLO-1 SLO-2	Lab 1: Learning to design amplifier and oscillator circuits	Lab 4: Design & analyze differential amplifier with resistive load	Lab 7: Design and analyze RC oscillators	Lab 10: BJT & FET Current Sources	Lab 13: Design and analyze differential amplifier with active load
S-6	SLO-1	AC analysis of Common-Base BJT amplifier configuration using hybrid-π model	AC analysis of Common-Gate MOSFET amplifier configuration	Practical Feedback Amplifier Circuits	Maximum dissipation hyperbola	Analysis of CE BJT amplifier circuit with active load

	SLO-2	*Problem solving*	*Problem solving*	*Problem solving*	*Heat sink*	*Problem solving*
S-7	SLO-1	*AC analysis of Common-Collector BJT amplifier config. using hybrid-π model*	*AC analysis of Common-Drain MOSFET amplifier configuration*	*Oscillators: Principles of Oscillation*	*Class A amplifier*	*Analysis of CS FET amplifier circuit with active load*
	SLO-2	*Problem solving*	*Problem solving*	*Types of Oscillators*	*Problem solving*	*Problem solving*
S-8	SLO-1	*Multi-stage amplifier configurations: CE - CE, CE - CC amplifiers*	*BiFET amplifier configuration*	*Audio Frequency Oscillators: RC Phase-Shift Oscillator*	*Class B and Class AB push-pull amplifiers*	*DC and small-signal analysis of basic BJT differential pairs*
	SLO-2	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*
S 9-10	SLO-1	*Lab 2: Design and analyze BJT amplifier configurations*	*Lab 5: Design and analyze negative feedback amplifier configurations*	*Lab 8: Design and analyze LC oscillators*	*Lab 11: Design and analyze BJT CE amplifier with active load*	*Lab 14: Model Practical Examination*
	SLO-2					
S-11	SLO-1	*Multi-stage amplifier configurations: CE - CB, and CC - CC amplifiers*	*Low Frequency response analysis of a basic FET CS amplifier*	*Audio Frequency Oscillators: Wein Bridge Oscillator*	*Class C amplifiers*	*DC and small-signal analysis of basic FET differential pairs*
	SLO-2	*Problem solving*	*Problem Solving*	*Problem Solving*	*Problem solving*	*Problem solving*
S-12	SLO-1	*Low Frequency response analysis of a basic BJT CE amplifier*	*High Frequency response analysis of a basic FET CS amplifier*	*Radio Frequency Oscillators: Hartley Oscillator*	*Class D and Class E amplifiers*	*Analysis of BJT differential amplifier with active load*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem solving*	*Amplifier distortions*	*Problem solving*
S-13	SLO-1	*High Frequency response analysis of a basic BJT CE amplifier*	*Design problems in MOSFET amplifier configurations*	*Radio Frequency Oscillators: Colpitts & Clapp Oscillators*	*IC Biasing & Amplifiers with Active Load: BJT current sources: 2- & 3-transistor current sources*	*Analysis of FET differential amplifier with active load*
	SLO-2	*Problem Solving*	*Operational voltage levels*	*Problem solving*	*Problem solving*	*Problem solving*
S 14-15	SLO-1	*Lab 3: Design and analyze multistage amplifier configurations*	*Lab 6: Design and analyze MOSFET amplifier configurations*	*Lab 9: Classes of power amplifier (efficiency calculation)*	*Lab 12: Design and analyze FET CS amplifier with active load*	*Lab 15: End Semester Practical Examination*
	SLO-2					

Learning Resources	1. *David A. Bell, Electronic Devices and Circuits, 5th ed., Oxford University Press, 2015* 2. *Donald Neamen, Electronic Circuits: Analysis and Design, 3rd ed., McGraw-Hill Education, 2011* 3. *Muhammad Rashid, Microelectronic Circuits: Analysis & Design, 2nd ed., Cengage Learning, 2010* 4. *Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits: Theory and Applications, OUP, 2014*	5. *Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 11th ed., Pearson Education, 2013* 6. *Albert P. Malvino, David J. Bates, Electronic Principles, 8th ed., Tata McGraw Hill, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
r. Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18ECC202J	Course Name	LINEAR INTEGRATED CIRCUITS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC102J	Co-requisite Courses	18ECC201J	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Study the basic principles, configurations and practical limitations of op-amp			
CLR-2 :	Understand the various linear and non-linear applications of op-amp			
CLR-3 :	Understand the operation and analysis of op-amp oscillators, single chip oscillators and frequency generators			
CLR-4 :	Identify the active filter types, filter response characteristics, filter parameters and IC voltage regulators.			
CLR-5 :	Gain knowledge on data converter terminology, its performance parameters, and various circuit arrangements for A/D and D/A conversions.			
CLR-6 :	Gain hands-on experience to put theoretical concepts learned in the course to practice.			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Infer the DC and AC characteristics of operational amplifiers and its effect on output and their compensation techniques	3	80	70	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Elucidate and design the linear and non-linear applications of an opamp and special application ICs	3	85	75	-	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Explain and compare the working of multivibrators using special application IC 555 and general purpose opamp	3	75	70	-	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Classify and comprehend the working principle of data converters and active filters	3	85	80	-	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Illustrate the function of application specific ICs such as Voltage regulators, PLL and its application in communication	3	85	75	-	M	H	-	-	-	-	-	-	-	-	-	M	-	H
CLO-6 :	Analyze and design electronic circuits and systems using linear ICs, and take measurement of various analog circuits to compare experimental results in the laboratory with theoretical analysis	3	85	75	-	M	H	-	M	-	-	-	M	-	-	-	H	L	-

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Op-amp symbol, terminals, packages	Basic op-amp circuits: Inverting & Non-inverting voltage amplifiers	Waveform Generators: Sine-wave Generators - Design	Filters: Comparison between Passive and Active Networks	Digital to Analog Conversion: DAC Specifications
	SLO-2	Op-amp-Specifications	Voltage follower	Implementation & Solving problems	Active Network Design	Solving problems
S-2	SLO-1	Block diagram Representation of op-amp	Summing, scaling & averaging amplifiers,	Square Wave generators- Design	Filter Approximations	Weighted Resistor DAC
	SLO-2	Ideal op-amp & practical op-amp - Open loop & closed loop configurations	AC amplifiers	Implementation & Solving problems	Design of LPF & Solving problems	Solving problems
S-3	SLO-1	DC performance characteristics of op-amp	Linear Applications: Instrumentation Amplifiers	Triangle wave generators	Design of HPF & Solving problems	R-2R Ladder DAC
	SLO-2	Solving Problems	Instrumentation Amplifiers, Solving Problems	Saw-tooth Wave generators.	Design of BPF& Solving problems	Solving problems
S 4-5	SLO-1 SLO-2	Lab-1:Basic op-amp circuits	Lab 4: Comparators	Lab 7: Waveform generators: using op-amp & 555 Timer	Lab 10: Design of LPF, HPF, BPF and Band Reject Filters	Lab 13: Flash Type ADC
S-6	SLO-1	AC performance characteristics of op-amp	V-to-I Converters	IC 555 Timer: Circuit schematic	Design of Band Reject Filters	Inverted R-2R Ladder DAC
	SLO-2	Solving Problems	I-to-V converters	Operation and its applications	Solving problems	Monolithic DAC
S-7	SLO-1	Frequency response	Differentiators	IC 555 Timer: Monostable operation	State Variable Filters – All Pass Filters,	Analog to Digital conversion: ADC specifications
	SLO-2	Frequency response	Integrators	Applications & Solving problems	Solving problems	Solving problems

S-8	SLO-1	*Frequency compensation*	*Non-linear Applications: Precision Rectifiers*	*IC 555 Timer: Astable operation*	*Switched Capacitor Filters.*	*Ramp Type ADC*
	SLO-2	*Frequency compensation*	*Wave Shaping Circuits (Clipper and Clampers)*	*Applications & Solving problems*	*Solving problems*	*Solving problems*
S 9-10	SLO-1 SLO-2	*Lab 2: Integrators and Differentiators*	*Lab 5: Wave shaping circuits*	*Lab 8: Waveform generators: using op-amp & 555 Timer*	*Lab 11: IC Voltage regulators*	*Lab 14: Simulation experiments using EDA tools*
S-11	SLO-1	*Basic op-amp internal schematic*	*Log and Antilog Amplifiers,*	*PLL: Operation of the Basic PLL*	*Voltage Regulators: Basics of Voltage Regulator*	*Successive Approximation ADC*
	SLO-2	*operations of blocks*	*Analog voltage multiplier circuit and its applications,*	*Closed loop analysis of PLL*	*Specifications and characteristic parameters*	*Solving problems*
S-12	SLO-1	*Basic op-amp internal schematic*	*Operational Trans-Conductance Amplifier (OTA)*	*Voltage Controlled Oscillator*	*Linear Voltage Regulators using Op-amp,*	*Dual Slope ADC*
	SLO-2	*operations of blocks*	*Comparators : operation*	*Solving problems*	*IC Regulators (78xx, 79xx, LM 317, LM 337, 723),*	*Flash Type ADC,*
S-13	SLO-1	*Review of data sheet of an op-amp.*	*Comparators applications*	*PLL applications*	*Switching Regulators -operation*	*Solving problems on Flash Type ADC,*
	SLO-2	*Solving Problems*	*Sample and Hold circuit.*	*Solving problems*	*Types*	*Monolithic ADC*
S 14-15	SLO-1 SLO-2	*Lab 3: Rectifiers*	*Lab 6: Waveform generators: using op-amp & 555 Timer*	*Lab 9: Design of LPF, HPF, BPF and Band Reject Filters*	*Lab 12: R-2R ladder DAC*	*Lab 15: Simulation experiments using EDA tools*

Learning Resources

1. *Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, 4th ed., Prentice Hall, 2000*
2. *David A. Bell, Operational Amplifiers and Linear ICs, 3rd ed., OUP, 2013*
3. *Roy Choudhury, Shail Jain, Linear Integrated Circuits, 4th ed., New Age International Publishers, 2014*
4. *Robert F. Coughlin, Frederick F. Driscoll, Operational-Amplifiers and Linear Integrated Circuits, 6th ed., Prentice Hall, 2001*
5. *Sergio Franco, Design with operational amplifier and analog integrated circuits, McGraw Hill, 1997*
6. *LABORATORY MANUAL, Department of ECE, SRM University*
7. *David A Bell, Laboratory Manual for Operational Amplifiers & Linear ICs, 2nd ed., D.A. Bell, 2001*
8. *David La Lond, Experiments in Principles of Electronic Devices and Circuits, Delmar Publishers, 1993*
9. *Muhammed H Rashid, Introduction to PSpice using OrCAD for circuits and electronics, 3rd ed., Pearson, 2004*
10. *L. K. Maheshwari, M. M. S. Anand, Laboratory Experiments and PSPICE Simulations in Analog Electronics, PHI, 2006*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mr. Manikandan AVM, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. M. Sangeetha, SRMIST*

Course Code	18ECC203J	Course Name	Microprocessor, Microcontroller and Interfacing Techniques	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC103J	Co-requisite Courses	Nil	Progressive Courses	18ECE204J, 18ECE205J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand basic architecture of Intel 8086 microprocessor and Intel 8051 Microcontroller
CLR-2 :	Familiarize the students with the programming and interfacing of microprocessors and microcontrollers with memory and peripheral chips
CLR-3 :	Interface a microprocessor / microcontroller to external input/output devices and perform input/output device programming in assembly
CLR-4 :	Use the computer to write and assemble assembly language programs and also run them by downloading them to the target microprocessor
CLR-5 :	Understand the hardware and software interrupts and their applications, and as well the properties and interfacing of the parallel and serial ports
CLR-6 :	Provide strong foundation for designing real world applications using microprocessors and microcontrollers.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning: Level of Thinking (Bloom)	Learning: Expected Proficiency (%)	Learning: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PSO 1: Professional Achievement	PSO 2: Project Management Techniques	PSO 3: Analyze & Research
CLO-1 :	Apply a basic concept of digital fundamentals to Microprocessor based personal computer system	1	60	70	-	H	-	-	L	-	-	-	-	-	-		-	-	-
CLO-2 :	Solve basic binary math operations using the microprocessor. / microcontroller	2	60	70	M	-	-	-		-	-	-	-	-	-	M	-	-	-
CLO-3 :	Demonstrate programming proficiency using the various addressing modes of the target microprocessor / microcontroller	3	60	70	-	M	H	-	H	-	-	-	-	-	-		-	-	L
CLO-4 :	Distinguish and analyze the properties of Microprocessors & Microcontrollers.	1	60	70	-	M	-	-		-	-	-	-	-	-	H	-	-	-
CLO-5 :	Illustrate their practical knowledge through laboratory experiments.	3	60	70	-	M	M	-	H	-	-	-	-	H	-		-	-	H
CLO-6 :	Design, interface and program memory chips and various peripheral chips with microprocessor / microcontroller	3	60	70	-	-	M	-	H	-	-	-	-		-	H	L	-	M

		Learning Unit / Module 1: Intel 8086 – Architecture, Signals and Features	Learning Unit / Module 2: Programming with Intel 8086	Learning Unit / Module 3: 8086 Interfacing with Memory and Programmable Devices	Learning Unit / Module 4: Intel 8051 – Architecture and Programming	Learning Unit / Module 5: Interfacing of 8051
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Introduction: History of computers, Block diagram of a microcomputer	Addressing modes of 8086	Semiconductor memory interfacing	Introduction: Differences between microprocessor and microcontroller	8051 parallel ports, and
	SLO-2	Intel 80x86 evolutions		Dynamic RAM interfacing	Intel's family of 8-bit microcontrollers, and feature of 8051 microcontroller	its programming
S-2	SLO-1	Features of 8086 microprocessor	Instruction Set of 8086: Data Transfer Instructions	Programmable Peripheral Interface 8255	Architecture of 8051	8051 timers, and
	SLO-2	Register organization of 8086	Example programs	Interfacing 8255 with 8086 and programming		its programming
S-3	SLO-1	Architecture of 8086	Data Conversion Instructions, Arithmetic Instructions	Interfacing ADC with 8086 and programming	Signal descriptions of 8051	8051 interrupts, and
	SLO-2		Example programs	Interfacing DAC with 8086 and programming		its programming
S-4,5	SLO-1	**Lab-1: (a) Learning to Program with 8086 processor kit; Learning the hardware features of the 8086 processor kit**	**Lab-4: General Purpose Programming in 8086**	**Lab-7: Interfacing DAC / ADC with 8086 / 8051**	**Lab-10: Programming timer / counter in 8086 / 8051**	**Lab-13: Simulation of 8051 using Keil Software**
	SLO-2					
S-6	SLO-1	Instruction queue and pipelining	Logical instructions and Processor control instructions	Stepper Motor interfacing	Register set of 8051	8051 serial port, and

	SLO-2	*Segmentation of memory used with 8086*	*Example programs*		*Operational features of 8051*	*its programming*
S-7	***SLO-1***	*Methods of generating physical address in 8086*	*String instructions*	*Programmable Interval Timer 8254*	*Memory and I/O addressing by 8051*	*Interfacing program memory with 8086*
	SLO-2	*Pin signals of 8086: Common signals*	*Example programs*	*Interfacing 8254 with 8086 and programming*	*Interrupts and Stack of 8051*	*Interfacing data memory with 8086*
S-8	***SLO-1***	*Minimum mode signals*	*Branch Instructions*	*Programmable Interrupt Controller 8259*	*Addressing modes of 8051*	*Interfacing input devices: push-button / matrix keypad*
	SLO-2	*Maximum mode signals*	*Example programs*	*Interfacing 8259 with 8086 and programming*		*Example programs*
S-9,10	***SLO-1***	*Lab-2: General Purpose Programing in 8086*	*Lab-5:* ***Simulation of 8086 using MASM Software / 8086 Emulator***	***Lab-8: Interfacing DC motor / stepper motor / servo motor with 8086 / 8051***	***Lab-11: Programming interrupts in 8086 / 8051***	***Lab-14: Model Practical Exam***
	SLO-2					
S-11	*SLO-1*	*Minimum mode 8086 system, and*	*Assembly Language Programming of 8086*	*Programmable Keyboard / Display Controller 8279*	*8051 Instruction Set: Arithmetic and Logical Instructions*	*Interfacing display devices: LED / 7-segment / LCD displays*
	SLO-2	*Timings*	*Assembly Language Programming of 8086*	*Interfacing 8279 with 8086 and programming*	*Example Programs*	*Example programs*
S-12	*SLO-1*	*Maximum mode 8086 system, and*	*Stack structure, and*	*Programmable Communication Interface 8251 USART*	*Data Transfer Instructions*	*Interfacing DAC*
	SLO-2	*Timings*	*related programming*	*Interfacing 8251 with 8086 and programming*	*Example Programs*	*Interfacing ADC*
S-13	*SLO-1*	*Intel 8088 Microprocessor: Pins signals and Architecture*	*Interrupt structure, and*	*DMA Controller 8257*	*Boolean Variable Instructions and Branch Instructions*	*Interfacing DC motor / stepper motor / servo motor*
	SLO-2	*Differences between 8086 & 8088 microprocessors*	*related programming*	*Interfacing 8257 with 8086 and programming*	*Example Programs*	*Example programs*
S-14,15	*SLO-1*	***Lab-3:*** *General Purpose Programing in 8086*	***Lab-6: Interfacing 8255 with 8086 / 8051***	***Lab-9: General Purpose Programming in 8051***	***Lab-10: Programming serial communication in 8086 / 8051***	***Lab-15: End-Semester Exam***
	SLO-2					

Learning Resources	1. *K. M. Bhurchandi and A. K. Ray, "Advanced Microprocessors and Peripherals-with ARM and an Introduction to Microcontrollers and Interfacing ", Tata McGraw Hill, 3rd edition 2015* 2. *Muhammad Ali Mazidi and Janice GillispieMazidi, "The 8051 - Microcontroller and Embedded systems", 7th Edition, Pearson Education, 2011.* 3. *Doughlas.V.Hall, "Microprocessor and Interfacing : Programming and Hardware", 3rd edition, McGraw Hill, 2015*	4. *Kenneth.J.Ayala, "8051 Microcontroller Architecture, Programming and Applications", 3rd edition, Thomson, 2007* 5. *Subrataghoshal " 8051 Microcontroller Internals Instructions ,Programming And Interfacing",2nd edition Pearson 2010* 6. *Yu-cheng Liu, Glenn A.Gibson, "Microcomputer systems: The 8086/8088 family-Architecture,programming and design",2nd edition, Prentice Hall of India,2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECC204J	Course Name	DIGITAL SIGNAL PROCESSING	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC104T	Co-requisite Courses	Nil	Progressive Courses	18ECE243J, 18ECE244J, 18ECE245T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1 :	Understand the operations involved in digital conversion of analog signals.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	Realize a digital filter in direct, cascade and parallel forms. Perform efficient computation of DFT using radix 2 FFT			
CLR-3 :	Design digital FIR filter using windowing technique and frequency sampling methods.			
CLR-4 :	Design IIR filters using both direct method and method involving conversion of analog filter to digital filter			
CLR-5 :	Understand sampling rate conversion and apply it for applications like QMF, sub band coding.			
CLR-6 :	Utilize the techniques for digital conversions, filter designs and multi rate signal processing to solve real time problems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Determine the knowledge of sampling and quantization and understand the errors that arise due to quantization.	1	80	70	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Understand the concept of DFT and its efficient computation by using FFT algorithm.	1	75	70	-	M	-	-	-	-	-	-	-	-	-	-	-	-	
CLO-3 :	Design FIR filters using several methods	3	75	70	-	M	H	-	-	-	-	-	-	-	-	-	-	-	H
CLO-4 :	Design IIR filters using several methods	3	75	70	-		H	-	-	-	-	-	-	-	-	-	-	-	H
CLO-5 :	Discuss the basics of multirate DSP and its applications.	1	70	70	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Apply the concepts of digital filter designs and multi rate signal processing for real time signals	2	70	70	-	M	-	-	-	-	-	-	-	-	-	-	M	-	-

		Learning Unit / Module 1: Signals and Waveforms	Learning Unit / Module 2: Frequency Transformations	Learning Unit / Module 3: FIR Filters	Learning Unit / Module 4: IIR Filters	Learning Unit / Module 5: Multirate signal Processing
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Basic Elements of DSP	Realization of digital filters Direct form of realization	Design of Linear Phase FIR filters General consideration	Design of digital IIR filters Comparison of FIR and IIR filters	Introduction to Multirate signal processing
	SLO-2	Advantages and applications of DSP	Cascade form of realization	Causality and its implication Characteristics of practical frequency selective filters	Analog IIR filter design	Decimation
S-2	SLO-1	Continuous Time vs Discrete time signals	Parallel form of realization	Frequency response of symmetric FIR filter	Properties of Butterworth filters	Interpolation
	SLO-2	Continuous valued vs discrete valued signals	Introduction to DFT	N is odd	Properties of chebyshev filters Comparison of Butterworth and chebyshev filters	Spectrum of interpolated signal
S-3	SLO-1	Concepts of frequency in analog signals	Computation of DFT	Frequency response of symmetric FIR filter	Analog IIR filter design	Sampling rate conversion by a rational factor I/D
	SLO-2	Continuous and discrete time sinusoidal signals	Properties of DFT Periodicity, linearity and symmetry properties	N is even	Design of low pass Butterworth filter	Anti-aliasing and anti-imaging filters
S-4	SLO-1	**Lab 1 :Generation of basic signals**	**Lab 7: Linear convolution**	**Lab 13: Design of digital FIR Low Pass and High Pass filter using rectangular window**	**Lab 19: Design of analog Butterworth filter**	**Lab 25: Interpolation**
	SLO-2					
S-5	SLO-1	**Lab 2: Unit step, ramp and impulse**	**Lab 8: Circular convolution**	**Lab14: Design of digital FIR Band Pass and Band Stop filter using rectangular window**	**Lab 20: Design of analog Chebyshev filter**	**Lab 26: Effect of interpolation in frequency domain**
	SLO-2					
S-6	SLO-1	Sampling of analog signals Sampling theorem	Circular convolution	Frequency response of antisymmetric FIR filter	Analog IIR filter design	Polyphase structure of decimator Polyphase decimation using z transform

	SLO-2	Aliasing Quantization of continuous amplitude signals	Matrix method and concentric circle method	N is odd and N is even	Design of low pass Chebyshev filter	Polyphase structure of interpolator Polyphase interpolation using z transform
S-7	SLO-1	Analog to digital conversion Sample and hold,	Efficient Computation of the DFT	Design of FIR filters Fourier series method	Design of digital filters Impulse invariance method	Advantages of multirate DSP
	SLO-2	Quantization and coding	Divide and Conquer Approach to Computation of the DFT Using FFT	Need for filter design using window Comparison of various windowing techniques	Design of digital filters Bilinear transformation	Applications of multirate DSP
S-8	SLO-1	Oversampling A/D converters	N Point DFT Decimation-in-Time FFT Radix-2 FFT Algorithm	Filter Design using windowing technique	Design of digital filters Impulse invariance method	Practical Applications of multirate DSP
	SLO-2	Digital to analog conversion Sample and hold	N Point DFT Decimation-in-Frequency FFT	Rectangular window	Design of digital filters Bilinear transformation	interfacing of digital systems with different sampling rates
S-9	SLO-1	Lab 3: Generation of waveforms	Lab9: Autocorrelation and cross correlation	Lab 15: Design of digital FIR Low Pass and High Pass filter using Hanning and Hamming window	Lab 21: Design of digital Butterworth filter using impulse invariance method	Lab 27: Decimation
	SLO-2					
S-10	SLO-1	**Lab 4: Continuous and discrete time**	**Lab10: Spectrum analysis using DFT**	**Lab 16: Design of digital FIR Band Pass and Band Stop filter using Hanning and Hamming window**	**Lab 22: Design of digital Butterworth filter using bilinear transformation**	**Lab 28: Effect of decimation in frequency domain**
	SLO-2					
S-11	SLO-1	Oversampling D/A converters	Radix-2 FFT Algorithm Implementation of FFT Using DIT	Filter Design using windowing technique Hanning window	Design of digital Chebyshev filters	Practical Applications of multirate DSP Sub band coding of speech signals
	SLO-2	Quantization noise	Implementation of FFT Using DIF	Filter Design using windowing technique Hamming window	Impulse invariance method	Filter banks Analysis filter bank
S-12	SLO-1	Errors due to truncation	IDFT	Filter Design using windowing technique	Design of digital Chebyshev filters	Synthesis filter bank
	SLO-2	Probability of error	Using DIT FFT	Blackmann window	Bilinear transformation	Subband coding filterbank
S-13	SLO-1	Errors due to rounding	IDFT	Design of FIR filters	Frequency transformation in analog domain	Quadrature Mirror Filter
	SLO-2	Probability of error	Using DIF FFT	Frequency sampling method	Frequency transformation in digital domain	Alias free filter bank
S-14	SLO-1	**Lab 5: Study of sampling theorem**	**Lab 11: Efficient computation of DFT using FFT**	**Lab 17: Design of digital FIR Low Pass, High Pass, Band pass and band stop filter using Blackmann window**	**Lab 23: Design of digital Chebyshev filter using impulse invariance method**	**Lab 29: Design of anti-aliasing filter**
	SLO-2					
S-15	SLO-1	**Lab 6: Aliasing effects**	**Lab12: Computation of IDFT**	**Lab 18: Design of digital FIR filter using frequency sampling method**	**Lab 24: Design of digital Chebyshev filter using bilinear transformation**	**Lab 30: Design of anti-imaging filter**
	SLO-2					

Learning Resources	1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing, Principles, Algorithms and Applications", Pearson Education, 4th edition, 2014 2. Alan V. Oppenheim, Ronald W. Schafer, "Discrete-Time Signal Processing", Pearson Education, 1st edition, 2015	3. Sanjit Mitra, "Digital Signal Processing –A Computer Based Approach", McGraw Hill, India, 4th Edition, 2013. 4. Fredric J. Harris, "Multirate Signal Processing for Communication Systems",1st edition, Pearson Education, 2007

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Code	18ECC205J	Course Name	ANALOG AND DIGITAL COMMUNICATION	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18MAB203T	Co-requisite Courses	Nil	Progressive Courses	18ECC301T, 18ECC302J, 18ECE221T & 18ECE223T
Course Offering Department	ECE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Introduce and Understand the need for modulation, various Amplitude modulators/demodulators, frequency modulators and demodulators
CLR-2 :	Comprehend the radio transmitters and receivers using the modulators and demodulators and to analyze the noise performance
CLR-3 :	To introduce basics of Digital modulation and detection techniques
CLR-4 :	To analyze the pass band data transmission techniques in terms of probability of error
CLR-5 :	To introduce basics of spread spectrum techniques and information theory concepts
CLR-6 :	Gain hands-on experience to put theoretical concepts learned in the course to practice.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Understand the concepts of analog modulation and demodulation techniques	2	80	70
CLO-2 :	Learn the function of radio transmitters and receivers and familiarize with noise performance of various receivers	2	85	75
CLO-3 :	Understand various digital modulation schemes and matched filter receiver	2	75	70
CLO-4 :	Understand and analyze various digital pass band data transmission schemes	2	85	80
CLO-5 :	Understanding data transmission using spread spectrum and error coding techniques	2	85	75
CLO-6 :	Analyze the operation of analog and digital communication systems and take measurement of various communication systems to compare experimental results in the laboratory with theoretical analysis	2	85	75

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
M	-	-	-	-	-	-	-	-	H	-	-	H	-	-
-	M	H	-	-	-	-	-	-	-	-	-	H	-	-
M	-	-	-	-	-	-	-	-	-	-	-	-	M	H
-	-	-	M	-	-	-	-	-	-	-	-	-	M	-
-	H	-	-	-	-	-	-	-	-	-	-	M	-	H
-	-	H	-	H	-	-	-	H	-	-	M	-	M	H

		Analog Modulation	Radio Transmitters and Receivers	Digital Modulation System and Baseband Detection	Passband Data Transmission	Spread Spectrum Techniques and Information theory Concepts
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Modulation, Need for Modulation,	AM transmitter : Low Level,	Pulse modulation systems, Overview of PAM,PWM,PPM	Overview of ASK, FSK, PSK	Spread spectrum Communications, Frequency Hopping Spread Spectrum (FHSS)
	SLO-2	Amplitude Modulation, Types of Amplitude Modulation	AM transmitter : High Level Transmitter	Pulse modulation systems, Overview of PAM,PWM,PPM	Overview of ASK, FSK, PSK	Spread spectrum Communications, Frequency Hopping Spread Spectrum (FHSS)
S-2	SLO-1	Double sideband Full carrier	FM transmitter: Direct Method	Pulse modulation systems, Sampling and quantization	Generation, Signal Space Diagram and detection of FSK	Direct Sequence Spread Spectrum (DSSS)
	SLO-2	Double sideband Full carrier	FM transmitter: Direct Method	Pulse modulation systems, Sampling and quantization	Generation, Signal Space Diagram and detection of FSK	Direct Sequence Spread Spectrum (DSSS)
S-3	SLO-1	Double sideband Suppressed carrier	FM transmitter: Indirect Method	PCM systems	Probability of Error for FSK	Direct Sequence Spread Spectrum (DSSS)
	SLO-2	Single sideband Suppressed carrier, VSB	FM transmitter: Indirect Method	Bandwidth of PCM, PCM TDM signal multiplexing, Limitations of PCM system	Probability of Error for FSK	Code Division Multiple Access of DSSS
S 4-5	SLO-1	**Lab-1: AM modulator and Demodulator**	**Lab-4: Pre emphasis and De-emphasis**	**Lab-7: DPCM and its Demodulation**	**Lab-10: QPSK Modulation and Demodulation**	**Lab-13: *Mini Project***
	SLO-2					

S-6	**SLO-1**	Generation of AM waves: Linear method-Collector modulator	Classification of radio receiver, Functions and Characteristics of radio receiver	Data formatting	Generation, Detection, Signal Space Diagram of PSK	Code Division Multiple Access of DSSS
	SLO-2	Generation of AM waves: Linear method-Collector modulator	Tuned Radio Frequency receiver	Data formatting	Generation, Detection, Signal Space Diagram of PSK	OFDM Communication
S-7	**SLO-1**	Non-linear Modulation-Balanced Modulator	*Super-heterodyne receiver- AM*	Differential PCM (DPCM)	Probability of Error for PSK	OFDM Communication
	SLO-2	Non-linear Modulation-Balanced Modulator	*Super-heterodyne receiver- AM*	Differential PCM (DPCM)	Probability of Error for PSK	OFDM Communication
S-8	SLO-1	Demodulation of AM waves : Linear diode detector	*Super-heterodyne receiver- FM*	Delta modulation (DM)	Generation, signal space diagram and detection of QPSK	Measures of Information
	SLO-2	Demodulation of AM waves : Linear diode detector	*Super-heterodyne receiver- FM*	Delta modulation (DM), Noise in DM	Generation, signal space diagram and detection of QPSK	Measures of Information
S 9-10	SLO-1	**Lab-2: DSB-SC modulator and demodulator**	**Lab-5: PAM,PPM,PWM modulation and demodulation**	**Lab-8: DM and its Demodulation**	**Lab-11: DPSK Modulation and Demodulation**	**Lab-14: *Model Practical Exam***
	SLO-2					
S-11	SLO-1	Frequency modulation, Types of FM	*Sources of Noise*	Demodulation and detection process	Probability of Error for QPSK	Source encoding, Shannon's Channel capacity theorem
	SLO-2	Narrow Band FM, Wide Band FM, Phase modulation	*Sources of Noise*	Demodulation and detection process	Probability of Error for QPSK	Shannon's Channel capacity theorem
S-12	SLO-1	Generation of Narrowband FM	*Noise in AM (Envelope Detection),*	Maximum likelihood receiver structure, Matched filter receiver	Generation, signal space diagram and detection of π/4 QPSK	Linear block codes
	SLO-2	Generation of Narrowband FM	*Noise in AM (Envelope Detection),*	Maximum likelihood receiver structure, Matched filter receiver	Generation, signal space diagram and detection of π/4 QPSK	Linear block codes
S-13	SLO-1	Demodulation of FM : Foster seely discriminator	*Noise in FM*	Probability error of the Matched filter, Inter symbol interference, Eye pattern	Generation, signal space diagram and detection of QAM	Cyclic codes
	SLO-2	Demodulation of FM : Foster seely discriminator	*Threshold effect, Pre-emphasis and De-emphasis*	Probability error of the Matched filter, Inter symbol interference, Eye pattern	Generation, signal space diagram and detection of QAM	Cyclic codes
S 14-15	SLO-1	**Lab-3: FM Modulator and Demodulator**	**Lab-6: Pulse Code Modulation and Demodulation**	**Lab-9: PSK Modulation and Demodulation**	**Lab-12: BER performance analysis of various Modulation Schemes**	**Lab-15: University Practical Exam**
	SLO-2					

Learning Resources	1. *Simon Haykin and Michael Moher, "Communication Systems," 5th edition, John Wiley & Sons, 2013* 2. Singh. R. P & Sapre. S. D, "Communication Systems: *Analog & Digital," 3rd edition, McGrawHill Education, Seventh Reprint, 2016.* 3. Simon Haykin, "Communication Systems", John Wiley & Sons, 4th Edition, 20008. 4. Bernard Sklar, "Digital Communication, Fundamentals and Application", Pearson Education Asia, 2nd Edition, 2001	5. Taub & Schilling, "Principle of Communication Systems", McGraw Hill Inc, 2nd Edition, 2003. 6. John G. Proakis, "Digital Communication", McGraw Hill Inc, 5th Edition, 2008. 7. B.P. Lathi, "Modern Digital and Analog Communication System", Oxford University Press, 3rd Edition, 2005. 8. Shu Lin, Daniel Costello, "Error control coding – Fundamentals and Applications", Prentice Hall, Upper Saddle River, NJ, 2nd Edition, 2004. 9. *Lab Manual*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*Mrs. S. Vasanthadev Suryakala, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECC206J	Course Name	VLSI Design	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC103J	Co-requisite Courses	Nil	Progressive Courses	18ECE301J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Use Verilog HDL as a design-entry language for FPGA in electronic design automation of digital circuits
CLR-2 :	Design, construct and simulate VLSI adders and multipliers.
CLR-3 :	Understand MOSFET operation
CLR-4 :	Implement a given logic function using appropriate logic styles for improved performance
CLR-5 :	Understand the basic processes in IC fabrication, steps in the fabrication of MOS ICs, and as well the layout design rules.
CLR-6 :	Use modern engineering tools such as HSPICE / Modelsim / Xilinx to carry out design experiments and gain experience with the design and analysis of MOS circuits and systems.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Design and implement digital circuits using Verilog HDL to simulate and verify the designs.	3	85	75	-	H	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Design general VLSI system components, adder cells and multipliers to address the design of datapath subsystem.	3	85	75	-	H	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Examine the characteristics of MOS transistors	2	80	70	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Analyze CMOS inverter and other complex logic gates designed using different logic styles	2	80	70	-	L	L	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Explain how the transistors are built, and understand the physical implementation of circuits.	2	80	70	-	L	L	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Use HSPICE computer analysis program and Verilog HDL for simulation and analysis of MOS circuits and building blocks	3	85	75	-	M	M	-	H	-	-	-	H	M	L	M	-	-	M

Duration (hour)		Learning Unit / Module 1: Introduction to Verilog HDL & Coding	Learning Unit / Module 2: Subsystem Design	Learning Unit / Module 3: MOS Transistor	Learning Unit / Module 4: CMOS Inverter and Circuit Design Styles	Learning Unit / Module 5:
		15	15	15	15	15
S-1	SLO-1	Introduction to HDL & Verilog HDL	**General VLSI System Components:** Multiplexers	**Generic overview of the MOS device:** MOS transistor symbols	**CMOS Inverter Characteristics:** Operation and properties of static CMOS inverter	**Properties of basic materials used in microelectronics:** Silicon, Silicon dioxide
	SLO-2	Introduction to Verilog HDL, modules and ports	Decoders	MOS structure demonstrating (a) accumulation, (b) depletion, and (c) inversion; nMOS transistor demonstrating cutoff, linear, and saturation regions of operation	VTC of static CMOS inverter	Polysilicon and Silicon Nitride
S-2	SLO-1	**Lexical Conventions:** White Space and Comments, Operators	Comparators	**MOS Transistor under Static Conditions:** The threshold voltage	DC Inverter Calculations	**Basic Processes in Integrated-Circuit Fabrication:** Wafer Formation, Photolithography, Well and Channel Formation
	SLO-2	Numbers, Strings, Identifiers, System Names, and Keywords	priority encoder	Resistive operation	Symmetrical Inverter	Silicon Dioxide (SiO_2), Isolation, Gate Oxide
S-3	SLO-1	**Verilog Data Types:** Nets, Register Variables, Constants	shift and rotate operations	Saturation region	Inverter switching characteristics	Gate and Source/Drain Formations, Contacts and Metallization, Passivation, Metrology
	SLO-2	Referencing Arrays of Nets or Regs	**Adders:** Standard adder cells	Current-voltage characteristics	Output capacitance	**Some Recurring Process Steps:** Diffusion and Ion Implantation, Deposition, Etching, Planarization
S-4, 5	SLO-1	**Lab-0: Verilog Operators:**		**Lab-6:** Realization of VLSI multipliers - I		

	SLO-2	*Arithmetic Operators, Bitwise Operators, Reduction Operators, Logical Operators, Relational Operators, Shift Operators, Conditional Operator, Concatenation Operator, Expressions and Operands, Operator Precedence*	***Lab-3:** Design using FSM and ASM charts*		***Lab-9:** Design and Analysis of CMOS Inverter using HSPICE*	*Lab-12: Design and Analysis of 4-input Dynamic NAND gate using HSPICE*
S-6	**SLO-1**	***Verilog modelling:** Gate-level modelling*	*Ripple Carry Adder (RCA)*	***Dynamic behavior:** MOSFET Capacitances, viz., MOS structure capacitances*	***Secondary Parasitic Effects:** Leakage Currents, Parasitic Resistances*	*Simplified CMOS Process flow*
	SLO-2	*Realization of Combinational and sequential circuits*	*Carry Look-Ahead Adder (CLA)*	*Channel capacitance and Junction (or, depletion) capacitances*	*Inverter layout*	
S-7	**SLO-1**	*Compilation and simulation of Verilog code*	*Carry Select Adder (CSL)*	*Parasitic Resistances, viz., Drain and Source Resistance, Contact Resistance*	***Power-Delay Product:** Static Power Consumption*	***Layout design rules:** Well rules, transistor rules*
	SLO-2	*Test bench*	*Carry Save Adder (CSA)*	***Non-ideal I-V effects:** Mobility Degradation, Velocity Saturation*	*Dynamic Power Consumption, Total Power Consumption, PDP*	*Contact rules, metal rules, via rules and other rules*
S-8	**SLO-1**	*Dataflow modelling*	*Carry Skip Adder (CSK)*	*Channel Length Modulation, Threshold Voltage Effects*	***CMOS Circuit Design Styles:** Static CMOS logic styles*	*Gate Layouts*
	SLO-2	*Realization of Combinational and sequential circuits*	*Carry Bypass Adder (CBA)*	*Leakage, Temperature Dependence, Geometry Dependence, Subthreshold Current*	*CMOS circuits, pseudo-nMOS, tristate circuits, clocked CMOS circuits*	*Stick diagrams*
S-9, 10	**SLO-1**	***Lab-1:** Realization of combinational and sequential circuits using gate-level and dataflow modeling*	***Lab-4:** Realization of VLSI adders - I*	***Lab-7:** Realization of VLSI multipliers - II*	***Lab-10:** (a) Design and Analysis of complex CMOS gate using HSPICE (b) Design and Analysis of Pseudo-NMOS gates using HSPICE*	*Lab-13: Model Practical Examination*
	SLO-2					
S-11	*SLO-1*	*Behavioral modelling*	***Multipliers:** Overview of multiplication (unsigned multiplication, shift/add multiplication algorithms, multiplication of signed numbers, types of multiplier architectures)*	***Short-channel MOSFETS:** Hot carriers, Lightly-Doped Drain (LDD)*	*Differential Cascade Voltage Switch Logic (DCVSL), Pass Transistor Logic (PTL)*	***CMOS Process Enhancements:** Transistors (Multiple Threshold Voltages and Oxide Thicknesses, Silicon-on-Insulator, High-k Gate Dielectrics, Higher Mobility, Plastic Transistors,)*
	SLO-2	*Realization of Combinational and sequential circuits*	*Braun multiplier*	*MOSFET scaling*	***Dynamic CMOS logic styles:** Basic dynamic logic*	
S-12	*SLO-1*	*Switch-level modelling*	*Baugh-Wooley multiplier*	***Short-channel effects:** Negative Bias Temperature Instability (NBTI), oxide breakdown*	*Signal integrity issues in dynamic design*	*Interconnects*
	SLO-2	*Realization of MoS circuits*	*Wallace Tree multiplier*	*Drain-Induced Barrier Lowering (DIBL), Gate-Induced Drain Leakage (GIDL), Gate Tunnel Current*	*Signal integrity issues in dynamic design*	*Circuit elements*
S-13	*SLO-1*	*Design using FSM*	*Booth multiplier*	*Tutorials*	***Domino Logic Circuits:** Differential Domino logic, multiple-output domino*	*Beyond conventional CMOS*
	SLO-2	*Realization of sequential circuits*	*Booth multiplier*	*Tutorials*	*Compound domino, NORA, TSPC*	*Tutorials*
S-14, 15	*SLO-1*	*Lab-2: (a) Realization of digital circuits using behavioral modeling (b) Realization of MOS circuits using switch-level mdeling*	***Lab-5:** Realization of VLSI adders - II*	*Lab-8: Realization of RAM & ROM*	***Lab-11:** (a) Design and Analysis of AND/NAND gate in DCVSL using SPICE (b) Design and Analysis of Pass-Transistor gates and CPL gates using HSPICE*	*Lab-14: End-Semester Practical Examination*
	SLO-2					

Learning Resources	*9. Jan Rabaey, Anantha Chandrakasan, B Nikolic, "Digital Integrated Circuits: A Design Perspective". Second Edition, Feb 2003, Prentice Hall of India.* *10. Weste, Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", 4th edition, Addision-Wesley, 2011.* *11. Wayne Wolf, "Modern VLSI Design: IP-based Design", 4th edition, PHI, 2009.*	*12.R. Jacob Baker, "CMOS Circuit Design, Layout, and Simulation", Wiley, (3/e), 2010.* *13.John P. Uyemura, "CMOS Logic Circuit Design", Kluwer, 2001.* *14.S. Palnitkar , Verilog HDL – A Guide to Digital Design and Synthesis, Pearson , 2003* *15.Paul. R.Gray, Robert G. Meyer, "Analysis and Design of Analog Integrated Circuits", Wiley, (4/e), 2001.* *16.M.D.Ciletti , Modeling, Synthesis and Rapid Prototyping with the Verilog HDL, Prentice Hall, 1999*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. J. Manjula, SRMIST*

Course Code	18ECC301T	Course Name	Wireless Communication	Course Category	C	Professional Core	L	T	P	C
							3	1	0	4

Pre-requisite Courses	18ECC205J, 18ECC105T	Co-requisite Courses	Nil	Progressive Courses	18ECE220T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the elements of Wireless Communication and mobile communications
CLR-2 :	Understand the Mobile Radio Wave Propagation - Large Scale Fading
CLR-3 :	Analyze how to apply Mobile Radio Wave Propagation - Small Scale Fading
CLR-4 :	Study the Capacity and Diversity concepts in wireless communications
CLR-5 :	Acquire the knowledge of Wireless System and Standards
CLR-6 :	Understand and design various wireless systems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
		1	2	3
CLO-1 :	Acquire the knowledge of Wireless communication and basic cellular concepts	2	75	60
CLO-2 :	Understand` the essential Radio wave propagation and mobile channel models	2	75	60
CLO-3 :	Familiarize about Various performance analysis of mobile communication system.	2	75	60
CLO-4 :	Attain the knowledge of Diversity and capacity concepts	2	75	60
CLO-5 :	Be familiar with the various standards of Mobile Communication Systems	2	75	60
CLO-6 :	Explore the various concepts of wireless communication, its design with respect to fading and link performance	2	75	60

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
H	-	-	-	-	-	-	-	-	-	-	M	M	-	L
H	H	H	H	-	-	-	-	-	-	-	M	M	-	H
H	H	H	-	-	-	-	-	-	-	-	-	-	-	H
H	H	-	-	-	-	-	-	-	-	-	-	-	-	H
H	-	-	-	-	-	-	-	-	-	-	M	M	-	L
H	H	H	H	M	-	-	-	-	M	-	M	M	-	H

Duration (hour)		Wireless communication: Mobile communications	Large Scale Fading	Small Scale Fading	Improvement on Link performance	Wireless systems and standards
		12	12	12	12	12
S-1	SLO-1	Introduction to wireless communication and mobile radio communication	Introduction to Radio wave Propagation	Introduction Small scale multipath propagation	Introduction to diversity, equalization and capacity	AMPS Voice modulation Process
	SLO-2	Classification of wireless communications - simplex, half duplex, dull duplex	Large scale and small scale fading	Impulse response model of multipath channel		
S-2	SLO-1	Paging and Cordless systems	Friis transmission equation- Free space propagation model - pathloss model	Impulse response model of multipath channel	Space diversity	GSM system architecture and its interfaces
	SLO-2	Cellular telephone systems		Small scale multipath measurements - Direct Pulse measurement	Scanning diversity	
S-3	SLO-1	Timing diagram - landline to mobile	Two Ray model	Small scale multipath measurements - Sliding correlator measurement	Maximal ratio combiner	GSM frame structure
	SLO-2	Timing diagram - mobile to mobile		Small scale multipath measurements - Swept frequency measurement	Equal gain diversity	
S-4	SLO-1	Basic antenna parameters, Far field and near field	Simplified pathloss model	Parameters of mobile multipath channels - Time dispersion and Coherent bandwidth	Rake Receiver	GSM speech operations input - output
	SLO-2	Frequency reuse, sectored and omni-directional antennas	Emperical model - Okumara			
S-5	SLO-1	Channel assignment strategies	Emperical model - Hata model	Parameters of mobile multipath channels - Doppler spread and Coherent time	Capacity in AWGN	Forward CDMA process
	SLO-2	Handoff and its types	Emperical model - Walfish and bertoni model			
S-6	SLO-1	Interference and system capacity	Piecewise linear model - log normal model	Types of fading: Flat and Frequency selective fading	Capacity of flat fading channels	Reverse CDMA Process
	SLO-2					

S-7	**SLO-1**	Trunking and Grade of Service	Shadowing	Types of fading: Flat and Frequency selective fading	Equalizer and its mode	Multicarrier modulation
	SLO-2		Combined pathloss and shadowing			
S-8	**SLO-1**	Cell splitting	Outage Probabilty	Types of fading: Fast and Slow fading	Adaptive equalizer block diagram	OFDM Transmitter Block diagram
	SLO-2					
S-9	**SLO-1**	Sectoring	Cell Coverage Area	Types of fading: Fast and Slow fading	Types of Equalizers - elementary level only	OFDM Receiver Block diagram
	SLO-2					
S-10	**SLO-1**	Microcell zone concepts	*Solving problems – Brewster angle*	Ricean distribution	Introduction to MIMO antennas	Importance of Cyclic Prefix
	SLO-2					
S-11	**SLO-1**	*Umbrella cells*	*Solving problems –empirical model*	Rayleigh distribution	Introduction to MIMO antennas	Case study - Modern antennas
	SLO-2					
S-12	**SLO-1**	*Solving Problems*	*Solving problems – friis transmission formula*	*Solving problems – Doppler effect*	*Case study :Recent trends in Diversity and MIMO antennas*	Case study - Modern antennas
	SLO-2					

Learning Resources	1. *Rappaport.T.S., "Wireless Communications: Principles and Practice", 2nd Edition, Pearson, 2011.* 2. *John D Kraus , Ronald J Marhefka, Ahmed S Khan "Antenna and Wave Propagation", 4th Edition, Tata McGraw Hill, 2010* 3. *Constantine Balanis. A, "Antenna Theory: Analysis and Design", 3rd Edition, John Wiley, 2012.* 4. *Andreas.F.Molisch., "Wireless Communications", Wiley, 2nd Edition-2005, Reprint-2014*	5. *Andrea Goldsmith, " Wireless Communications", Cambridge University Press, Aug 2005* 6. *Schiller, "Mobile Communications", Pearson Education Asia Ltd., Reprint 2012* 7. *Lee W.C.Y., " Mobile Communications Engineering: Theory and Applications", McGraw Hill, New York, 2nd Edition, 1998*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. Sandeep Kumar P, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. T. Ramarao, SRMIST*

Course Code	18ECC302J	Course Name	Microwave & Optical Communications	Course Category	C	*Professional Core*	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*18ECC205J*	Co-requisite Courses	*Nil*	Progressive Courses	*18ECE226T & 18ECE323T*
Course Offering Department	*Electronics and Communication Engineering*	**Data Book / Codes/Standards**		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	*2*	*3*
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Identify Microwave active devices and Microwave generators*			
CLR-2 :	*Analyze Microwave passive devices*			
CLR-3 :	*Explore Microwave Measurements*			
CLR-4 :	*Analyze Optical Fibers Optical Sources, Amplifier and Transmitter Optical Detectors , Receiver and Performance Measurements*			
CLR-5 :	*Explore Optical Communication System Design and Concepts*			
CLR-6 :	*Analyze Microwave and optical components*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	Acquire knowledge on the theory of microwave transmission, microwave generators and associated components.	*2*	80	*70*
CLO-2 :	Analyse microwave passive devices and components.	*2*	80	*70*
CLO-3 :	Understand microwave measurements and associated techniques with equipment	*2*	80	*70*
CLO-4 :	Familiarize with the fundamentals of light transmission through fiber	*2*	80	*70*
CLO-5 :	Design a basic optical communication system.	*2*	80	*70*
CLO-6:	Understand the working principle of microwave components , Microwave measurements, optical sources, detector and fibers	*2*	80	*70*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
H	-	-	*L*	-	-	-	-	-	-	-	-	-	-	*L*
H	*M*	*H*	*H*	-	-	-	-	-	-	-	-	*L*	-	*M*
H	*M*	*H*	*M*	-	-	-	-	-	-	-	-	*M*	-	*H*
H	*H*	-	*M*	-	-	-	-	-	-	-	-	*L*	-	*L*
H	*H*	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*M*
H	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*

Duration (hour)		**15**	**15**	**15**	**15**	**15**
S-1	**SLO-1**	Introduction to microwaves and optical communications	High frequency parameters: S parameters and S matrix analysis for N-port microwave device	Impedance matching.	Elements of Optical fiber communication	Point-to-Point link –Analog system design considerations and design steps
	SLO-2					
S-2	**SLO-1**	History of Microwave Engineering, Microwave transmission and Applications; Maxwell Equations	Directional coupler	VSWR and Impedance measurement	Functional block diagram of a Transmitter and receiver module	Point-to-Point link – Digital system design considerations and design steps
	SLO-2					
S-3	**SLO-1**	Microwave Tubes	E and H plane Tee	Measurement of Power	Optical fiber structure, Light Propagation in Optical fibers: Ray theory , Total Internal reflection, Skew rays	Digital Link Design: Link power budget
	SLO-2	Klystron amplifier				
S-4-5	**SLO-1**	**Lab- 1 Characteristics of Reflex Klystron**	**Lab- 4 Gain and radiation pattern of Horn antenna**	**Lab- 7 Practice session**	**Lab- 10 Measurement of Numerical Aperture, propagation and bending losses of optical fiber**	**Lab- 13 Design of basic Optical Communication system using computational tool**
	SLO-2					
S-6	**SLO-1**	Reflex Klystron oscillators	Magic Tee	Measurement of Frequency and Q factor	Optical Sources: Light source materials, LED Structures	Rise time budget
	SLO-2					
S-7	**SLO-1**	Magnetron oscillators	Microwave Circulators, Isolators	Insertion loss measurements	LED Characteristics	Overview of Analog links: Radio over Fiber;
	SLO-2					
S-8	**SLO-1**	Microwave Bipolar Transistors	Attenuators and Phase Shifters	Attenuation measurements	Semiconductor Laser Diode, Laser Characteristics	Key link parameters
	SLO-2	**Field effect transistor**				

S-9-10	**SLO-1**	**Lab- 2 Study of power distribution in Directional coupler, E plane, H plane and Magic Tee**	**Lab- 5 Characteristics of filters, Microstrip patch antenna and parallel line coupler**	**Lab- 8 DC characteristics of LED and Laser diode**	**Lab- 11 Analysis of Analog optical link**	**Lab- 14 Practice Session**
	SLO-2					
S-11	**SLO-1**	IMPATT, TRAPATT and Tunnel diode	Rectangular Waveguides	Measurement of Scattering parameters	Optical Detectors: PIN and APD photo detector	Multichannel System: Need for multiplexing
	SLO-2					Operational principles of WDM, DWDM
S-12	**SLO-1**	Gunn diode	Rectangular Waveguides	Measurement of Scattering parameters	Responsivity and efficiency of APD	WDM Components: Coupler/Splitter, Fabry Perot Filter
	SLO-2					
S-13	**SLO-1**	Gunn Oscillation modes	Power Dividers	Functioning details of Vector Network Analyzer; Signal Analyzer; Spectrum analyzers	Fiber attenuation and dispersion	WDM Components: Optical MEMS switches
	SLO-2					
S-14-15	**SLO-1**	**Lab- 3 Impedance measurement by slotted line method**	**Lab- 6 Design of RF Filters and Amplifier using computational tool**	**Lab- 9 DC characteristics of PIN and APD photo-diode**	**Lab- 12 Analysis of Digital optical link**	**Lab- 15 Study experiment - Gunn Diode (Microwave) and Optical WDMA (Optical)**
	SLO-2					

Learning Resources	1. David M. Pozar, "Microwave Engineering", 4th Edition, John Wiley & Sons, 2012. 2. David M. Pozar, "Microwave & RF Design of Wireless Systems", John Wiley & Sons, 2001. 3. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Edition, Pearson Education, 2013. 4. Robert. E. Collin, "Foundations for Microwave Engineering", 2nd edition, Wiley, Reprint 2014. 5. Annapurna Das, Sisir K. Das, "Microwave Engineering", 3rd Ed., McGraw Hill, 2015. 6. I. Hunter, "Theory and design of microwave filters", The Institution of Engineering &Technology, 2001. 7. Keiser G, "Optical Fiber Communication Systems", 5th Edition, 6th Reprint, McGraw Hill Education (India), 2015. 8. Vivekanand Mishra, Sunita P. Ugale, "Fiber Optic Communication: Systems and Components", Wiley-India, 1st edition, 2013 9. Djafar.K. Mynbaev and Lowell and Scheiner, "Fiber Optic Communication Technology", Pearson Education Asia, 9th impression, 2013 10. John M. Senior, " Optical fiber Communications: Principles and Practice", Pearson Education, 3rd Edition, 2009 11. R.P. Khare, "Fiber Optics and Optoelectronics", Oxford University Press, 2007. 12. 12. Rajiv Ramaswami, Kumar N. Sivaranjan, Galen H.Sasaki "Optical Networks A practical perspective", 3nd edition, 2013

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. T. Ramarao, SRMIST*

Course Code	18ECC303J	Course Name	Computer Communication Networks	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18CSS101J	Co-requisite Courses	Nil	Progressive Courses	18ECE320T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1 :	Introduce the basic concepts in the field of computer networks.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	Understand the functional aspects of OSI model architecture.			
CLR-3 :	Acquire knowledge of the Network Layer protocols			
CLR-4 :	Analyze the various issues and challenges of Transport Layer.			
CLR-5 :	Familiarize the various Application Layer Protocols.			
CLR-6:	Utilize the networking concepts to analyze the performance of Routing protocols.			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Express the basic services and concepts related to internetworking.	1	60	65	-	-	-	-	-	-	H	-	-	-	-	M	-	-	-	
CLO-2 :	Explain the basic OSI model architecture and its lower layer functions.	1	60	65	-	-	M	-	-	-	L	-	-	-	-	-	-	-	H	
CLO-3 :	Illustrate the various Network Layer concepts, mechanisms and protocols.	2	65	65	-	-	H	-	-	L	M	-	-	-	-	-	-	-	-	
CLO-4 :	Describe the services and techniques of Transport Layer.	1	60	65	-	-	-	-	-	-	M	-	-	-	-	-	-	-	H	
CLO-5 :	Discuss the various services and protocols in Application Layer.	1	60	65	-	-	M	-	-	-	-	-	-	-	-	-	-	-	H	
CLO-6 :	Analyze the various Networking concepts and Routing protocols.	2	60	65	-	-	-	-	L	-	-	-	-	-	-	M	-	-	H	

Duration (hour)		DATA COMMUNICATION & NETWORKING BASICS	OSI LOWER LAYERS	NETWORK LAYER	TRANSPORT LAYER	APPLICATION LAYER
		15	15	15	15	15
S-1	SLO-1	Introduction to Data Communication and Networking	Network models	*Introduction to Network Layer*	*Introduction to Transport Layer*	*Introduction to Application Layer*
	SLO-2	Data transfer modes-Serial and Parallel transmission	OSI layer architecture	Need for Internetworking	*TCP/IP Model*	*Application Layer Paradigms*
S-2	SLO-1	Protocols & Standards	Data Link Layer-Introduction	*Addressing-Classful*	*User Datagram Protocol(UDP)*	*Client Server Interaction*
	SLO-2	Layered Architecture	Link Layer Addressing	*Addressing-Classful*	*User Datagram Protocol(UDP)*	*Client Server Interaction*
S-3	SLO-1	Principles of Layering & Description	Error Detection	*Addressing-Classless*	*Transmission Control Protocol(TCP)*	*SIP*
	SLO-2	Brief description of concepts in OSI & TCP/IP model	Error Detection	*Addressing-Classless*	*Transmission Control Protocol(TCP)*	*SIP*
S 4-5	SLO-1	**Lab 1: To build and configure a simple network of four nodes connected with point-to-point links**.	**Lab 4: To simulate token ring protocol and to study its performance.**	***Lab 7:To simulate CSMA/CA protocol and to study its performance***	***Lab 10: Implementation and study of Selective Repeat protocol.***	***Lab 13: Create a Socket (TCP&UDP) between two computers and enable file transfer between them.***
	SLO-2					
S-6	SLO-1	Switching Types- Circuit- & Packet switching	Error Correction	*Network Layer Protocol-IPV4*	*TCP Services & Features*	*Compression Techniques*
	SLO-2	Switching Types- Message switching, Comparison of switching types	Error Correction	*Internet Protocol(IP)-IPV4*	*TCP Services & Features*	*Compression Techniques*
S-7	SLO-1	LAN, MAN & WAN	Data link control-LLC	*Internet Protocol(IP)-IPV6*	*Congestion Control*	*Introduction to Cryptography*

	SLO-2	LAN, MAN & WAN	Data link control-LLC	*Internet Protocol(IP)-IPV6*	*Congestion Control*	*Types, Attacks and Services*
S-8	**SLO-1**	Network topologies-Types	Data link control-MAC	*Routing Protocols- Distance Vector& Link State*	*Congestion Control*	*DES*
	SLO-2	Comparison of topologies	Data link control-MAC	*Routing Issues-Delivery, Forwarding and Routing*	*Congestion Control*	*DES*
S 9-10	**SLO-1**	**Lab 2: *To simulate star and bus network topologies.***	**Lab 5: Implementation of Error detection and Correction scheme.**	***Lab 8: Implementation and study of stop and wait protocols***	***Lab 11: To configure a network using Link State Routing protocol .***	***Lab 14: Implementation of Data Encryption and Decryption.***
	SLO-2					
S-11	**SLO-1**	*IEEE standards for LAN-Ethernet*	*Flow & Error Control Protocol*	Routing Information Protocol-RIP	*QOS-Quality of Service*	*RSA*
	SLO-2	*Types of Ethernet*	*Flow & Error Control Protocol*	Routing Information Protocol-RIP	*QOS-Quality of Service*	*RSA*
S-12	**SLO-1**	*Token Bus*	*ARQ Schemes*	*Open Shortest Path First-OSPF*	*Techniques to improve QOS*	*Email*
	SLO-2	*Token Ring*	*ARQ Schemes*	*Open Shortest Path First-OSPF*	*Techniques to improve QOS*	FTP
S-13	**SLO-1**	*FDDI*	*HDLC*	*Border Gateway Protocol-BGP*	*Techniques to improve QOS*	*HTTP*
	SLO-2	*FDDI*	*HDLC*	*Border Gateway Protocol-BGP*	*Techniques to improve QOS*	*SNMP*
S 14-15	**SLO-1**	***Lab 3: To simulate token bus protocol***	**Lab 6:To simulate CSMA/CD protocol**	***Lab 9: Implementation and study of Go back N protocol.***	***Lab 12: To configure a network using***	***Lab 15: Mini Project***
	SLO-2	***and to study its performance.***	**and to study its performance**		***Distance Vector Routing protocol.***	

Learning Resources	1. Behrouz A.Fehrouzan, "Data communication & Networking", Mc-Graw Hill, 5th Edition Reprint, 2014. 2. Andrew S.Tanenbaum, "Computer Networks", Pearson Education India, 5th Edition, 2013.	3. William Stallings, "Data & Computer Communication", Pearson Education India, 10th Edition, 2014. 4. James F. Kurose, Keith W. Ross, "Computer Networking: A Top–Down Approach Featuring the Internet", Pearson Education,6th Edition, 2013. 5. "Lab Manual" , Department of ECE, SRM Institute of Science and Technology

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Acquire skills to solve real world problems in Analog and Digital Electronics (Discrete & IC)*			
CLR-2 :	*Acquire skills to solve real world problems in Analog and Digital Communication*			
CLR-3 :	*Acquire skills to solve real world problems in Signals & Systems, and DSP*			
CLR-4 :	*Acquire skills to solve real world problems in Microprocessors & Microcontrollers, and VLSI Design*			
CLR-5 :	*Acquire skills to solve real world problems in Electromagnetics and Transmission Lines*			
CLR-6 :	*Acquire skills to solve real world problems in Microwave and Optical Communications*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Practice and gain confidence and competence to solve problems in Analog and Digital Electronics (Discrete & IC)*	*3*	*85*	*80*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-2 :	*Practice and gain confidence and competence to solve problems in Analog and Digital Communication*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-3 :	*Practice and gain confidence and competence to solve problems in Signals & Systems, and DSP*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-4 :	*Practice and gain confidence and competence to solve problems in Microprocessors & Microcontrollers, and VLSI Design*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-5 :	*Practice and gain confidence and competence to solve problems in Electromagnetics and Transmission Lines*	*3*	*85*	*80*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-6 :	*Practice and gain confidence and competence to solve problems in Microwave and Optical Communications*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*

Duration (hour)		3	3	3	3	3
S-1	SLO-1	***Tutorial on** Analog Electronics (Discrete & IC)*	***Tutorial on Digital Communication***	***Tutorial on Microprocessors & Interfacing***	***Tutorial on Transmission Lines***	***Tutorial on Optical Communication***
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	***Tutorial on Digital Electronics***	***Tutorial on Signals and Systems***	***Tutorial on Microcontrollers & Interfacing***	***Tutorial on VLSI Design***	*Model Test*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Model Test*
S-3	SLO-1	***Tutorial on Analog Communication***	***Tutorial on Digital Signal Processing***	***Tutorial on Electromagnetics***	***Tutorial on Microwave Communication***	*Final Test*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Final Test*

Learning Resources	*1. R.S.Khurmi, J.K.Gupta, Mechanical Engineering: Conventional and Objective Types, S.Chand & Co., 2018*	*2. R.K.Jain, Conventional & Objective Type Question & Answers on Mechanical Engineering for Competitions, Khanna Publishers, 2014*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	40%	-	30%	-	30%	-	30%	-	30%
	Understand										
Level 2	Apply	-	40%	-	40%	-	40%	-	40%	-	40%
	Analyze										
Level 3	Evaluate	-	20%	-	30%	-	30%	-	30%	-	30%
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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B. Tech in Electronics and Communication Engineering
(with Specialization in BioMedical Engineering)

2018 Regulations

Professional Elective Courses (E)

Department of Electronics and Communication Engineering
SRM Institute of Science and Technology
SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECE260J	Course Name	BIOMEDICAL INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC201J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Measure and interpret various physiological parameters			
CLR-2 :	Utilize the working of different monitoring equipment's			
CLR-3 :	Utilize the principle and working of different equipment's available for hemodynamic measurements			
CLR-4 :	Utilize the principle and working of different types of pulmonary function analyzers			
CLR-5 :	Utilize the principle and working of clinical laboratory equipment's			
CLR-6 :	The learner gains knowledge in application of various diagnostic medical devices and issues related to device safety			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Describe the origin of bio potential and its measurements using different type of electrodes	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	Illustrate working principle of cardiac function monitors and devices used for measurement of parameters such as blood pressure, blood flow, heart rate, cardiac output and blood oxygen content	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Analyze the components and working principle of pulmonary function measuring devices and patient monitoring systems	3	75	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-4 :	Interpret the working principle of different clinical laboratory equipment	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	Predict various electrical hazards and implement safety methods while using biomedical equipment	3	80	70	-	M	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-6 :	Summarize the working principles of different diagnostic instruments available for measuring the physiological variables	3	80	70	M	M	-	-	-	-	-	-	-	-	-	-	M	-	-

Duration (hour)		Biopotential Electrodes	Bio Signals Recording	Cardiac Function Measurements	Pulmonary Function Measurements and Patient Monitoring System	Bioanalytical Equipments and Patient Safety
		12	12	12	12	12
S-1	SLO-1	Cell structure and its functions, Physiological systems of the body	Electrical conduction system of the heart, Cardiac cycle	Haemodynamic pressure, Measurement of blood pressure: direct methods	Mechanism of respiration	Types of blood cells
	SLO-2	Cardiovascular system Respiratory system, Nervous system	ECG: origin, waveforms, characteristics, Einthoven triangle Lead configurations	Indirect methods: Oscillometric method, Auscultatory method, Rheographic method, Ultrasonic method for blood pressure measurement	Pulmonary function measurements, Respiratory volumes and capacities	Calculation of cell size
S-2	SLO-1	Basic Medical Instrumentation system, Sources of Biomedical Signals	Electrocardiograph, 12 lead ECG machine block diagram,	Blood flow measurement: Electromagnetic blood flow meters, Sine and square wave blood flowmeter	Spirometry: Basic spirometer, wedge spirometer, Ultrasonic spirometer	Blood cell counters –Microscopic method, Automatic optical method
	SLO-2	Resting and Action potential, Nernst equation, Goldman equation, Hodgkin-Huxley model	Common mode and interference reduction circuits	Ultrasonic blood flow meter: Doppler shift principle, Pulsed Doppler blood flowmeter	Pneumotachometers: turbine type Pneumotachometer, Fleisch-type & Venturi type Pneumotachometers	Electrical conductivity based method, Coulter counter, Automatic recognition
S 3-4	SLO-1	Lab1: Language of Anatomy, Overview of organ system	Lab4: Recording and analysis of ECG signal	Lab7: Recording and analysis of heart sounds	Lab10: Pulmonary function measurement and analysis using spirometer	Lab13: Mini project
	SLO-2					
S-5	SLO-1	Recording Electrodes: Electrode tissue interface, Metal electrolyte interface	Cardiac arrhythmias	NMR blood flow meter	Measurement of gas volume: Flow-Volume curve, Area of the flow volume, Nitrogen wash out technique	Differential counting of cells, Spectrophotometer Colorimeters
	SLO-2	Electrolyte skin interface	Characteristics and origin of heart sound, Phonocardiography	Laser Doppler blood flowmeter	Electro spirometer	Flame photometers, Selective ion electrodes, ion analyser

S-6	**SLO-1**	*Polarization: polarizable and non-polarizable electrodes, Skin contact impedance*	*EEG : origin, waveforms and their characteristics, 10-20 electrode placement system*	*Cardiac output measuring techniques: dye dilution method, Indicator dilution, thermal dilution method*	*Pulmonary function analyzers*	*Patient safety: Electric shock hazards*
	SLO-2	*Surface Electrodes: Silver-Silver chloride electrodes, Floating and pre-gelled electrodes , Pasteless electrodes*	*Block diagram and working of EEG*	*Measurement of cardiac output from aortic pressure waveform*	*Impedance pneumography*	*Gross shock and effects of electric current on human body*
S 7-8	**SLO-1**	*Lab2: Study of different types of electrodes*	*Lab5: Recording and analysis of EEG signal*	*Lab8: Measurement of blood pressure using Sphygmomanometer/LabVIEW Biomedical workbench*	*Lab11: Measurement of Heartrate using LabVIEW Biomedical workbench*	*Lab14: Mini project*
	SLO-2					
S-9	**SLO-1**	*Air jet electrodes, Micro Electrodes*	*Other Biomedical recorders: Vectorcardiograph*	*Impedance technique and bioreactance method*	*Respiratory gas analyzers: Infrared gas analyser, Paramagnetic oxygen analyser*	*Micro current shock*
	SLO-2	*Needle Electrodes, Ion sensitive field effect transistors, Transcutaneous electrodes*	*Apexcardiograph*	*Ultrasound method and CO2 rebreathing method*	*Thermal conductivity analyser, nitrogen gas analyser, Polarographic oxygen analyser*	*Ventricular fibrillation- electrophysiology*
S-10	**SLO-1**	*Biochemical electrodes: pH*	*Recording and analysis of EMG signal, Biofeedback Instrumentation*	*Oximeters- Invitro, Invivo oximetry and types of oximeters*	*Heart rate measurement, Monitoring of foetal heart rate*	*Leakage current and its types*
	SLO-2	*Biochemical electrodes: pO2, pCO2*	*Measurement of BSR, Measurement of GSR*	*Central monitoring & Bedside monitoring system*	*Measurement of respiration rate: displacement method, thermistor method, CO2 method, Apnoea detector*	*Precautions and safety codes, Electrical safety analyser*
S 11-12	**SLO-1**	*Lab3: Design of bio amplifier*	*Lab6: Recording and analysis of EMG signal*	*Lab9: Recording and analysis of signals using patient monitoring system*	*Lab12: Mini project*	*Lab15: Model Practical Exam*
	SLO-2					

Learning Resources	1. *R.S. Khandpur, Handbook of Biomedical instrumentation, 3rd ed., Tata McGraw Hill, 2014*	2. *John G. Webster, Medical Instrumentation application and design, 4th ed., Wiley, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	*1. Dr. A. K. Jayanthy, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2.* ***Dr. T. Jayanthi****, SRMIST*
. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE261T	Course Name	MEDICAL IMAGING TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Utilize the physics behind x ray imaging and Computed tomography
CLR-2 :	Utilize the hardware and techniques involved in nuclear imaging
CLR-3 :	Utilize the properties and techniques in ultrasound imaging
CLR-4 :	Utilize the physics behind magnetic resonance and techniques in resonance imaging
CLR-5 :	Utilize the principle behind modern imaging techniques
CLR-6 :	Utilize the imaging techniques for various applications

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Analyze the physics behind x ray imaging and Computed tomography	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-2 :	Illustrate the hardware and techniques involved in nuclear imaging	3	80	70	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-3 :	Describe the properties and techniques in ultrasound imaging	3	75	70	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-4 :	Analyze the physics behind magnetic resonance and techniques in resonance imaging	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-5 :	Identify the principle behind modern imaging techniques	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-6 :	Apply the imaging modality for interpretation	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L

Duration (hour)		X-ray and Computed Tomography	Nuclear Imaging	Ultrasound Imaging	Nuclear Magnetic Resonance Imaging	Modern optical imaging
		9	9	9	9	9
S-1	SLO-1	Production of x-ray – Basic principle and its block diagram	Nuclear medicine – Radio isotopes in medical diagnosis	Diagnostic ultrasound	Principles of NMR imaging system	Spectroscopy – Introduction
	SLO-2	Voltage Generators , Collimators and Grids , Automatic Exposure Control	Physics of radioactivity	Physics of ultrasound	Free induction decay	Types of light sources
S-2	SLO-1	Visualization of x rays – X ray film and processing, Fluorescent screen	Radiation detectors – Ionization chamber	Generation and detection of ultrasound	NMR signal – Spin echo	Optical filters – Types
	SLO-2	Image intensifier	Scintillation detectors , Semiconductor detectors, Solid state detectors	frequency, active element diameter and focusing	T1 and T2 relaxation	Need for filters
S-3	SLO-1	Computed radiography - CR imaging	Pulse height analyser	Basic pulse echo apparatus	Pulse sequence	Monochromators - Prism
	SLO-2	CR image manipulation	Uptake monitoring system	System description	Repetition time, Echo time	Grating monochromators
S-4	SLO-1	Digital radiography	Rectilinear scanner	A scan - Introduction	Spin Echo Contrast Weighting – T1 weighting	Optical fibers – Need
	SLO-2	Flat panel detector	Radioisotope rectilinear scanner	Applications of A scan	T2 weighting , Spin proton density weighting	Various configurations using optical fibers
S-5	SLO-1	Mammography – Automatic exposure control	Gamma camera	M Mode principle	Localization MR signal -Magnetic field gradients	Polarizers – Introduction
	SLO-2	Mammography equipment's	Multi crystal gamma camera	Block diagram of an echocardiograph circuit	Slice select gradients	Types of polarisers
S-6	SLO-1	CT – Principle of CT imaging	Emission computed tomography- Principle	B scanner - Introduction	Frequency encode gradient	Fractional Flow Reserve – procedure

	SLO-2	*Beers law, Hounsfield unit*	*Principle of PET and SPECT scanner*	*Types of B scanner*	*Phase encoded gradient*	*Measurement , Interpretation of results , Advantages*
S-7	**SLO-1**	*CT scan – Tomographic acquisition*	*SPECT system description*	*Multi element array scanners*	*2D image acquisition*	*Microwave imaging – Need*
	SLO-2	*Generations of CT*	*Various detector configurations*	*Sequential array scanner and phased array scanner*	*Echo planar image acquisition*	*Applications of microwave imaging*
S-8	**SLO-1**	*Detectors – Scintillation crystal and Photomultiplier*	*PET system description*	*Modern Imaging systems – block diagram description*	*MRI scanner components*	*Optical coherence imaging – Introduction*
	SLO-2	*Xenon , scintillarc*	*Gantry and detector modules*	*Frame grabbers , Digital scan converters*	*Artifacts*	*Types – Time domain and Fourier domain*
S-9	**SLO-1**	*Data acquisition and Image reconstruction*	*Dual modality imaging – SPECT/CT*	*Doppler ultrasound*	*Functional MRI*	*Thermal imaging in medicine*
	SLO-2	*Filtered back projection and artifacts*	*PET / CT*	*Intravascular ultrasound techniques*	*MR spectroscopy*	*IR detectors , Block diagram of IR imaging*

Learning Resources	*1. Khandpur R.S, Hand-book of Biomedical Instrumentation, 2nd ed., Tata McGraw Hill, 2003* *2. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, 2nd ed., Prentice-Hall of India, 1997*	*3. William R. hendee, E, Russell Ritenour Medical imaging physics, 4th ed., 2002* *4. Wolfgang Drexler James G. Fijimoto, Optical coherence tomography technology and applications, 1st ed., Springer, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	*1. Dr. S. P. Angeline Kirubha, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr. P. Vinupritha, SRMIST*
. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE262T	Course Name	BIOMATERIALS AND ARTIFICIAL ORGANS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Identify the phenomena occurring between biomaterials and surrounding tissue in living organism
CLR-2 :	Acquire the skills on different classes of biomaterials with its degradation process.
CLR-3 :	Identify the suitable biomaterials for cardiovascular and orthopedic applications.
CLR-4 :	Acquire skills to handle different biomaterials for dental, eye and ear applications
CLR-5 :	Proficiency to have an insight on the regulatory approval procedure for artificial organs
CLR-6 :	Acquire the skills on suitable burn dressings and skin substitutes

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO-1: Problem Solving at the interface of Engg. & Medicine	PLO 14 PSO-2: Design & Develop Medical Devices	PLO 15 PSO-3: multidisciplinary research for health care solu
CLO-1 :	Analyze biocompatibility and testing of biomaterials	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-2 :	Identify relations between structure and properties of various biomaterials	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-3 :	Select materials with suitable properties in cardiovascular and orthopedic devices	3	75	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-4 :	Identify biomaterials in dental, vision and auditory devices	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-5 :	Analyze materials for artificial skin and drug delivery applications	3	80	70	M	-	-	-	-	-	-	M	-	-	-	-	-	-	-
CLO-6 :	Analyze the regulatory process for different artificial organs comprising codes, reliability, and device testing	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-

Duration (hour)		Properties of biomaterials	Metals and ceramics	Biomaterials for cardiovascular and orthopedic applications	Biomaterials for eye, ear & dental applications	Biomaterials for artificial skin and drug delivery applications
		9	9	9	9	9
S-1	SLO-1	The nature of matter and materials	Metals: Basic Principles	Substitute Heart Valves	Dental implants to support dental prosthesis	Burn Dressings and Skin Substitutes: Artificial skin, Soft tissue replacement
	SLO-2	Mechanical properties of biomaterials	Stainless Steel, Titanium and Co-Cr alloys: Metallurgical and Chemical Considerations	Heart Valve Function and Dysfunction	Adhesives and Sealants to enhance bond strength and durability	Sutures and Alternatives to Suture
S-2	SLO-1	Physiochemical properties of biomaterials	Mechanical properties	Heart Valve Replacement and Repair	Ophthalmologic Applications: Overview of Eye Anatomy	Drug Delivery Systems: Principles, Origins, Evolution of Controlled Drug Delivery
	SLO-2	Biomaterial characterization – Analytical instruments	Corrosion behavior	Mechanical and Tissue Valve Replacement Devices: Types and Complications	Contact Lenses -General Properties and Corneal Requirements	Liposomes, Polymeric micelles
S-3	SLO-1	Cells: Function and response to Injury	Applications of Stainless steel, titanium, Co-Cr alloys	Trans catheter Valve Replacement	Contact Lens Materials - Surface Modifications	Polymeric and Albuminated Drug Nanoparticles, Dendrimers
	SLO-2	Tissues, the Extracellular Matrix, and Cell–Biomaterial Interactions	Various other types of metals with its biomedical applications	Engineered Heart Valves	Specialty Lenses - Contact Lens Solutions	Injected Depot DDS
S-4	SLO-1	Host Reaction to biomaterials and their evaluation	Polymers: Basic principle	Angioplasty and Stents	Intraocular Lens Implants (IOLS): Scientific Perspective	Implants and Inserts, Infusion Pumps, Inserts
	SLO-2	Inflammation, Wound healing, and the foreign body response	Polyacrylate, Polyamide and Polyolefins: Properties of biomaterials	Vascular Grafts	Optics of the Eye and Cataracts Emerging Functional Variations of IOLS	Smart DDS, Environmentally Response systems
S-5	SLO-1	Systemic toxicity and hypersensitivity	Applications of polymeric biomaterials	Stent Grafts	Biomaterials for IOLS	Transdermal DDS, Passive and Active Transdermal Delivery Systems
	SLO-2	In Vitro assays to assess cell and tissue compatibility in biomaterial/medical device	Various other types of metals with its biomedical applications	Engineered Vascular Grafts	IOLS with Variations of Optical Function	Oral drug delivery – Controlled release in the GI tract
S-6	SLO-1	Evaluation for regulatory purposes	Ceramics: Basic Principles, Bioactive Glasses and Glass-Ceramics	Cardiovascular Devices: Pacemakers and Icds (For Cardiac Arrhythmias)	Corneal Inlays and Onlays	Regulatory Overview for Medical Products Using Biomaterials:

						Global Regulatory Strategy - Design Control and Risk Analysis
	SLO-2	*Application-Specific In Vitro assays considered in proof of concept testing*	*Calcium Phosphate Ceramics, Natural and Synthetic Hydroxyapatites, Alumina: Synthesis of ceramic materials*	*Cardiac Assist and Replacement Devices (For Heart Failure)*	*Synthetic Biomaterials in the Cornea - Optical Requirements - Biological Requirements - Permeable Intracorneal Lenses*	*Biocompatibility Assessment for Biomaterials in Medical Devices - Manufacturing Controls and Post Market Oversight*
S-7	**SLO-1**	*Future challenges in In Vitro Assessment of cell and tissue compatibility*	*Mechanical Properties and Porosity*	*Miscellaneous Cardiovascular Devices*	*Impermeable Intracorneal Lenses - Synthetic Materials for Corneal Onlays*	*Premarket Clearance, Premarket Approval (PMA)*
	SLO-2	*Selection of In Vivo tests according to intended use*	*Stability and Biocompatibility*	*Implantable Cardiac Assist Devices and IABPs*	*Glaucoma Drains and Implants*	*Clinical and Animal Trials of Unapproved Devices*
S-8	**SLO-1**	*Biomaterial and Device perspectives in In Vivo testing*	*Applications of ceramics biomaterials*	*Ventricular Assist Device and Blood-Contacting Materials*	*Retinal Prostheses and concerned biomaterials*	*Sterilization, Shelf-Life, and Aging*
	SLO-2	*Specific biological properties assessed by In Vivo tests*	*Various other types of metals with its biomedical applications*	*Orthopedic applications: Total hip replacement*	*Cochlear Prostheses – Overview of the Auditory System*	*Ethical Issues in Biomaterials and Medical Devices: Protection of Patients*
S-9	**SLO-1**	*Selection of animal models for In Vivo tests*	*Degradation of metallic and polymeric biomaterials*	*Knee replacement*	*Cochlear Prostheses - Materials and Electrode Arrays*	*Good Laboratory, Manufacturing and Clinical Practice*
	SLO-2	*Future Perspectives on In Vivo medical device testing*	*Degradation of ceramic biomaterials*	*Miscellaneous orthopedic Devices*	*The role of biomaterials in stimulating bioelectrodes- Active chemical processes and Passive chemical processes*	*Protection of Research Subjects - Conflicts of Interest*

Learning Resources	1. *David Williams., Essential biomaterials science, 1st ed., Cambridge University Press, 2014* 2. *Lysaght M, Webster T J., Biomaterials for artificial organs, 1st ed., Woodhead Publishing Limited, 2011*	3. *Buddy Ratner, Allan Hoffman, Frederick Schoen, Jack Lemons., Biomaterials Science - An Introduction to Materials in Medicine, 3rd ed., Academic Press, 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2.* ***Mr. S. Gnanavel,*** *SRMIST*
. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE263T	Course Name	BIOSENSORS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Utilize the various concepts and terminologies of measurement system
CLR-2 :	Utilize the working principles of transducers
CLR-3 :	Analyze the physiology of human sensory systems
CLR-4 :	Utilize the working principles of biological sensors
CLR-5 :	Analyze the medical applications of biosensors
CLR-6 :	Learn the modern sensors for medical diagnosis

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Identify the concepts of measurements and the errors associated with measurement	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	Analyze the working principles of transducers	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Evaluate the physiological functions of human sensory systems	3	75	70	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-4 :	Analyze the principles of various sensors used in medical diagnosis	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	Describe the various modern biosensors used in medical diagnosis	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-6 :	Implement the modern technologies in biosensors	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-

Duration (hour)		Fundamentals of measurement system	Transducers	Biological sensors	Biosensors	Fiber optic sensors
		9	9	9	9	9
S-1	SLO-1	Functional elements of an instrumentation system	Classification of transducers	Study of biological sensors in the human body: neuronal mechanism	Biosensors – Introduction	Fiber optic sensors: Introduction
	SLO-2	Functional elements of an instrumentation system	Classification of transducers	Study of biological sensors in the human body: neuronal mechanism	Biosensors – Introduction	Fiber optic sensors: Introduction
S-2	SLO-1	Static characteristics	Characteristics for selection of transducers	pacinian - functions	components of Biosensors	Fiber optic biosensors: Introduction
	SLO-2	Static characteristics	Characteristics for selection of transducers	pacinian - functions	components of Biosensors	Working and principle
S-3	SLO-1	Static characteristics	Resistive transducers: RTD	Chemoreceptor	Classification of biosensors	Optical biosensors for measurement of blood glucose level
	SLO-2	Static characteristics	Thermistor	Chemoreceptor	Classification of biosensors	Optical biosensors for measurement of blood glucose level
S-4	SLO-1	Dynamic characteristics	Resistive transducers: Strain gauge	hot and cold receptors	Biocatalysts based biosensor	Smart sensor: Introduction
	SLO-2	Dynamic characteristics	Resistive transducers: Strain gauge	hot and cold receptors	Biocatalysts based biosensor	Working
S-5	SLO-1	Errors in measurements: sources of errors	Piezoelectric effect transducer: Construction	baro receptors	Enzyme immobilisation	Applications of smart sensor
	SLO-2	Errors in measurements: sources of errors	Working	baro receptors	Enzyme immobilisation	Applications of smart sensor
S-6	SLO-1	Errors in measurements: types of errors	Hall effect transducer: Construction	sensors for smell	Glucose Biosensor	Lab on a chip- Introduction, Need

	SLO-2	*Errors in measurements: types of errors*	*Working*	*sensors for smell*	*Glucose Biosensor*	*Block diagram*
S-7	**SLO-1**	*Statistical analysis of data*	*Capacitive transducers*	*sensors for sound*	*bio affinity based biosensor*	*Applications*
	SLO-2	*Statistical analysis of data*	*Construction and Working*	*sensors for sound*	*bio affinity based biosensor*	*Advantages and Disadvantages*
S-8	**SLO-1**	*Standards: international standards, primary standards*	*Inductive transducers*	*sensors for vision*	*microorganism based biosensors*	*eNose: Construction*
	SLO-2	*secondary standards and working standards*	*Construction and Working*	*sensors for vision*	*microorganism based biosensors*	*Working*
S-9	**SLO-1**	*Calibration methodologies*	*Photomultiplier tube*	*Sensors for osmolality and taste*	*Advantages and limitations of Biosensor*	*Applications of eNose*
	SLO-2	*Calibration methodologies*	*Construction and Working*	*Sensors for osmolality and taste*	*Advantages and limitations of Biosensor*	*Applications of eNose*

Learning Resources	1. ***Sawhney A.K, A Course in electrical and electronic measurements and instrumentation, 19th ed., Dhanpat Rai & Co (P) Ltd, 2014*** 2. ***Patranabis D, "ensors and transducers", 2nd ed., Prentice Hall of India, 2004***	3. ***A. D. Helfrick, W. D. Cooper, Modern electronic instrumentation and measurement techniques, 4th ed., Prentice Hall of India, 1998.***

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	***1. Dr. D. Kathirvelu, SRMIST***
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2.* ***Mr. V. KarthikRaj****, SRMIST*
. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE264T	Course Name	DIAGNOSTIC AND THERAPEUTIC EQUIPMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Gain thorough knowledge about the working principle of coronary care equipments			
CLR-2 :	Understand the functioning and uses of different surgical equipments			
CLR-3 :	Gain knowledge about the different components and working principle of respiratory care equipments and Bone mineral density measuring techniques			
CLR-4 :	Comprehend about the different components and working principle of sensory diagnosis and therapeutic equipments			
CLR-5 :	Understand the functioning of different types of physiotherapy and			
CLR-6 :	Understand the functioning of electrotherapy equipments			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu.
CLO-1 :	Explain the working principle of coronary care equipments	3	80	75	H	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-2 :	Describe the functioning and uses of different surgical equipments	3	80	70	L	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-3 :	Give an overview about the different components and working principle of respiratory care equipments and Bone mineral density measuring techniques	3	75	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-4 :	Give an overview about the different components and working principle of sensory diagnosis and therapeutic equipments	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-5 :	Illustrate the functioning of different types of physiotherapy equipments	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-6 :	Illustrate the functioning of different types of electrotherapy equipments	3	80	70	H	-	-	-	-	-	-	-	-	-	-	-	L	-	-

Duration (hour)		Coronary care equipments	Surgical equipments	Respiratory care equipments and Bone mineral density measuring equipments	Sensory diagnosis equipments	Physiotherapy and electrotherapy equipments
		9	9	9	9	9
S-1	SLO-1	***Need for cardiac pacemaker***	*Principles of surgical diathermy unit*	*Mechanics of respiration, Artificial ventilation*	*Mechanism of hearing, sound conduction system*	***Short wave diathermy, Simplified circuit diagram, Methods of applying electrodes***
	SLO-2	***Types of pacemaker and different modes of operation***	***Surgical diathermy machine*** *Block diagram and description*	*Respiratory care equipment: humidifier*	***Measurements of sound, Transducers used to measure sound***	***Inductive and condenser method, Inductive heating by coil in drum***
S-2	SLO-1	***External pacemaker – Block diagram***	*Endoscopy basic components*	*Nebulizer, aspirators*	*Block diagram and description of basic audiometer*	***Micro wave diathermy, Production of microwaves***
	SLO-2	***Three types of External pacemaker based on the type of output waveform***	***Types of endoscopy – Fiber optic and rigid types***	*Ventilators –Functional diagram, Types of ventilator*	*pure tone audiometer*	***Simplified circuit diagram of micro wave diathermy***
S-3	SLO-1	***Implantable pacemakers, requirements, Classification codes for pacemakers***	*Applications of endoscopy- Laparoscope, gastro scope*	***Classification of ventilator***	*Speech audiometer*	***Ultrasonic therapy unit- Block diagram description***
	SLO-2	***Types of implantable pacemakers, Various pacing modalities in demand pacemaker***	*Applications of endoscopy- bronchoscope, arthroscopy*	***Ventilator- Microprocessor controlled ventilator***	***Calibration of audiometers***	***Dosage control in ultrasonic therapy unit***
S-4	SLO-1	***Ventricular synchronous demand pacemaker***	***Cobalt T-60 machine – Basic components***	***Electronics block diagram of ventilator***	*Block diagram and description of Bekesy audiometer system*	***Electro diagnosis and electrotherapy basics – Intensity time curve of muscles,***
	SLO-2	***Rate responsive pacemaker***	***Gamma Knife***	*Capnography – Block diagram description*	*Block diagram and description of Evoked response audiometry system*	***Different types of waveforms used in electrotherapy***

S-5	SLO-1	***Need for Defibrillator, AC Defibrillator***	*Cryogenic surgical techniques*	*Anesthesia machine – schematic diagram of an anesthesia machine*	*Hearing aids, Conventional analog type hearing aid*	***Electro diagnostic/ Stimulating unit – Schematic block diagram***
	SLO-2	***DC Defibrillator – schematic diagram***	*Applications of cryogenic surgery*	***Block diagram & description of an anesthesia monitor***	***Digital hearing aid***	***Interferential current therapy – Principle of generation of interference currents***
S-6	SLO-1	***Defibrillator electrodes, DC Defibrillator with synchronizer***	*Operating microscope – basic principle*	*Baby incubator – Principle of operation*	*cochlear implants*	***Transcutaneous electrical nerve stimulation***
	SLO-2	*Automatic or advisory external defibrillator (AED)*	*Operating microscope – components*	*Baby incubator – Block diagram description*	***Different types of cochlear implants***	***Spinal cord stimulator***
S-7	SLO-1	***Implantable Defibrillator architecture and types***	***Lithotripsy- Schematic of an acoustic shock wave pulse***	*BMD measurements: Single X-ray absorptiometry (SXA) – basic principle*	*Tonometry – Impression type, Applanation tonometry*	***Diaphragm pacing by radio frequency for treatment of Chronic ventilator insufficiency***
	SLO-2	***Pacer cardioverter defibrillator***	***The first Lithotripter machine***	*Single X-ray absorptiometry (SXA) – Instrumentation*	***Non-contact type tonometry***	***Deep brain stimulation***
S-8	SLO-1	***Defibrillator analyzer – block diagram***	*Modern lithotripter system – Block diagram description*	*Dual X-ray absorptiometry (DXA) - basic principle*	*Measurement of basal skin response and galvanic skin response - Principle*	***Bladder stimulator – schematic diagram of bladder stimulator***
	SLO-2	***Defibrillator protection circuit in ECG***	***Shock wave generator, Shock wave sources,***	*Dual X-ray absorptiometry (DXA) - Instrumentation*	*Measurement of basal skin response and galvanic skin response -* ***Block diagram***	***Circuit diagram of bladder stimulator***
S-9	SLO-1	***Heart lung machine***	***Focussing system, Coupling, Imaging systems in Lithotripsy machine***	*Quantitative ultrasound bone densitometer - basic principle*	***Biofeedback instrumentation – Basic principle***	***Phototherapy unit – Principle of operation and application***
	SLO-2	***Types of oxygenators used in Heart lung machine***	*laser lithotripsy*	*Quantitative ultrasound bone densitometer - Instrumentation*	***EMG feedback for rehabilitation study***	***Types of phototherapy unit***

Learning Resources

1. *R.S.Khandpur, Handbook of Bio-Medical instrumentation, 3rd ed., Tata McGraw Hill, 2014*
2. *Albert M.Cook and Webster. J.G, Therapeutic Medical Devices", 1st ed., Prentice Hall, 1982*
3. *Sydney Lou Bonnick, Lori Ann Lewis, Bone Densitometry and Technologists, 3rd ed., Springer, 2013*
4. *Cotton.P. B, and Williams. C. B., Endoscopic Equipment, in Practical Gastrointestinal Endoscopy: The Fundamentals, 6th ed., Wiley-Blackwell, 2008*
5. *Marc. Safran, Bobby. Chhabra. A., Mark. Miller.D, Primer of Arthroscopy, 2nd ed., Elsevier Health Sciences, 2010*
6. *Ventura, Risegari, The Art of Cryogenics Low-Temperature Experimental Techniques, 1st ed., Elsevier Science, 2007*
7. *Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, Bio-Medical Instrumentation and Measurements, 2nd ed., Pearson Education, 2007*
8. *John G.Webster, Specifications of Medical Instrumentation Application and Design, 4th ed., Wiley, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Course Code	18ECE265J	Course Name	BIOMEDICAL SIGNAL PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC204J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Utilize the characteristics of various bio signals
CLR-2 :	Utilize knowledge in time domain and frequency domain filtering techniques to remove noise from bio signals
CLR-3 :	Apply various signal processing techniques in analysis of ECG signals
CLR-4 :	Utilize knowledge in Wavelets and speech signal analysis
CLR-5 :	Analyze the characteristics of non-stationary signals
CLR-6 :	Analyze the classification of normal and abnormal ECG signal.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Analyze the physiological origin and characteristics of various biomedical signals	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Apply time-domain and frequency domain filtering techniques to remove noise from biomedical signals	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Analyze various signal processing methods to process the ECG and HRV signals.	3	75	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-4 :	Apply wavelet transform techniques to analyze the biomedical signal	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	Analyze the characteristics of non-stationary signals	3	80	70	M	-	M	-	M	-	-	-	L	L	M	-	M	-	L
CLO-6 :	Perform the classification of normal and abnormal signal	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		12	12	12	12	12
S-1	SLO-1	***Bioelectric signals-ENG, ERG***	***Time domain filters-Synchronized averaging***	***ECG waveform analysis***	*Introduction to wavelets*	*Analysis of non-stationary signals*
	SLO-2	***EOG , EEG signal characteristics***	***Moving averaging filters***	***Envelope Extraction and Analysis***	***Continuous and Discrete wavelet***	*Time variant system*
S-2	SLO-1	***ECG signal physiological origin***	***Frequency domain filters Removal of high frequency noise-Butterworth low pass filter***	***P wave detection***	*Discrete wavelet transform*	***Fixed segmentation***
	SLO-2	***characteristics***	***Design procedure***	***Estimation of R-R Interval***	*pyramid algorithm*	***Short time Fourier transform***
S 3-4	SLO-1	***Lab1: Representation of basic biosignals***	***Lab4: Design of Butterworth Low pass filter to remove high frequency noise***	***Lab7: Analysis of ECG signal***	*Lab 10: Wavelet transform for 1-D Signal Processing*	***Lab 13: Mini project***
	SLO-2					
S-5	SLO-1	***PCG signal***	***Removal of low frequency noise-Butterworth high pass filters***	***QRS complex detection-Template subtraction method***	*Comparison of Fourier transform and wavelet transform*	***Adaptive segmentation***
	SLO-2	***Characteristics***	***Removal of periodic artefacts-Notch & Comb Filter***	***Template correlation method***	*Comparison of Fourier transform and wavelet transform*	***Algorithm***
S-6	SLO-1	***VAG***	***Introduction to Adaptive filter***	***Derivative based method-High speed QRS detection algorithm,***	*Speech analysis – Cepstrum*	*Autocorrelation function method*
	SLO-2	***VMG***	*Adaptive noise canceller*	***High speed QRS detection algorithm***	*Homomorphic filtering of speech signals*	*generalized likelihood ratio*
S 7-8	SLO-1	***Lab2: Correlation of Biosignals***	***Lab5: Design of Butterworth high pass filter to remove low frequency noise***	***Lab8: Detection of QRS complex from ECG***	*Lab11: Analysis of speech signal*	***Lab 14: Mini project***
	SLO-2					

S-9	SLO-1	***Bioacoustic signal-Auscultation***	***Optimal Filtering: Wiener Filter***	***Simple high speed QRS width detection algorithm-Differentiation, smoothing***	*Time frequency representation*	*Classification of signal: Normal and ectopic ECG beats*
	SLO-2	*Voice, Korotkoff sound*	***Wiener Filter(Contd.)***	***Moving average integrator, thresholding***	*Spectrogram*	*Algorithm*
S-10	SLO-1	***Biomechanical Signal***	***Wiener Filter(Contd.)***	***Heart rate variability (HRV)-Introduction***	*Time scale representation*	*Case studies- in ECG and PCG*
	SLO-2	***Biochemical Signal***	***Wiener Filter***	***Time & Frequency domain methods***	*Scalogram*	*PCG and carotid pulse*
S 11-12	SLO-1 SLO-2	***Lab3: Analysis of EEG signal***	***Lab6: Design of Adaptive filters***	***Lab9: Analysis of Heart rate variability***	*Lab 12: Mini project*	*Lab 15: Model Practical Exam*

Learning Resources	1. *Rangaraj.M.Rangayyan, Biomedical signal processing, 2nd ed., Wiley-IEEE press, 2015* 2. *Reddy D.C, Biomedical signal processing: Principles and techniques, 2nd ed., Tata McGraw-Hill, 2005*	3. *Willis J. Tompkins, Bio**medical Digital Signal Processing, PHI, 2004***

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE266T	Course Name	BIOMEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Get an idea about the MEMS and Microsystem basics			
CLR-2 :	Understand the microsystem fabrication processes and materials used for MEMS			
CLR-3 :	Understand the micromachining processes			
CLR-4 :	Acquire the knowledge required for the development of microfluidic systems			
CLR-5 :	Identify the applications of bioMEMS in healthcare industry			
CLR-6 :	Understand the applications of MEMS and BioMEMS			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Analyze the working principle of MEMS & Microsystems in healthcare domain	3	80	75	M	-	L	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Explain the microsystem fabrication processes and materials used for MEMS	3	80	70	-	-	L	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Differentiate the various Micromanufacturing techniques in miniature applications	3	75	70	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Analyze the working principle of Microfluidic Systems in healthcare	3	80	75	-	-	M	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	Illustrate the concepts of BioMEMS with suitable examples	3	80	70	-	-	M	-	-	-	-	-	-	-	-	-	M	-	-
CLO-6 :	Analyze the applications of MEMS in Biomedical domain	3	80	70	M	-	L	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		Introduction to Microsensor and Microactuator	Materials for MEMS and basic fabrication Techniques	Basics of Micromachining	Microfluidics	BioMEMS
		9	9	9	9	9
S-1	SLO-1	MEMS and Microsystems- Introduction	Substrates and Wafers	Bulk micromanufacturing	Microfluidics Introduction	BioMEMS Introduction
	SLO-2	Advantages of MEMS & Microsystems	Silicon as a Substrate Material	Isotropic etching	Fluid Properties	Application of BioMEMS
S-2	SLO-1	Typical MEMS and Microsystem Products	Materials for MEMS: Silicon compounds	Anisotropic etching	Applications of Microfluidic Systems in biomedical	Lab on a chip
	SLO-2	Application of Microsystems in Healthcare Industry	Silicon Piezoresistor	Etch Stop Techniques	Fluid actuation methods	DNA Sensors
S-3	SLO-1	Microsensors- Acoustic wave sensor	Gallium arsenide	Etch Stop Techniques	Dielectrophoresis (DEP)	Hybridization Types
	SLO-2	Microsensors- Optical Sensors	Quartz	Dry Etching	Electrowetting	Microsystem approaches to PCR
S-4	SLO-1	Microsensors- Biomedical Sensors & Biosensors	Piezoelectric crystals	Dry Etching Techniques	Electrothermal	Microsystem approaches to PCR
	SLO-2	Chemical Sensors	Polymers	Dry Etching Techniques	Thermocapillary	Mobile Point of Care Monitors
S-5	SLO-1	Pressure Sensors	Packaging Materials	Surface Micromachining	Electroosmosis	Implantable MEMS for glaucoma therapy
	SLO-2	Thermal Sensors	Photolithography	Surface Micromachining Process Sequence	Optoelectrowetting (Light-actuated microfluidic device)	Implantable MEMS for glaucoma therapy

S-6	**SLO-1**	*Microactuator*	*Ion Implantation*	*LIGA Introduction*	*Microfluidic channel*	*MEMS based Implantable Drug Delivery System*
	SLO-2	*Different types of actuation*	*Diffusion*	*Application*	*Microdispenser*	*MEMS based Implantable Drug Delivery System*
S-7	**SLO-1**	*Application of Microactuations: Microgrippers*	*Oxidation*	*LIGA Process*	*Microneedle*	*Integrated microsystems for artificial retinal implants*
	SLO-2	*Application of Microactuations: Microvalve and Micropump*	*Chemical vapor deposition (CVD)*	*LIGA Process*	*Microfilter*	*Integrated microsystems for artificial retinal implants*
S-8	**SLO-1**	*Inch-Worm Technology*	*CVD Types*	*Merits and Demerits of Bulk Micromachining*	*Microseparator*	*MEMS-based neuronal intervention devices*
	SLO-2	*Micro-accelerators*	*Physical vapor deposition (PVD)*	*Merits and Demerits of Surface Micromachining*	*Microreactor*	*MEMS-based neuronal intervention devices*
S-9	**SLO-1**	*Examples of biomedical microsensors and microactuators*	*Epitaxy*	*Merits and Demerits of LIGA Process*	*Micromixer*	*Current Point of Care Technology*
	SLO-2	*Examples of biomedical microsensors and microactuators*	*Etching*	*Summary of Micromachining*	*Capillary Electrophoresis*	*Current Point of Care Technology*

Learning Resources

1. *Tai-Ran Hsu, MEMS & Microsystems- Design, Manufacture and Nanoscale Engineering, 2nd ed., John Wiley & Sons, 2008*
2. *Nitaigour Premchand Mahalik, MEMS, Tata McGraw Hill, 2008*
3. *Steven S.cSaliterman, Fundamentals of BioMEMS & Medical Microdevices,1st ed., International Society for Optical Engineering, 2006*
4. *Ellis Meng, Biomedical Microsystems, 1st ed., CRC Press, 2011*
5. *Simona Badilescu, Muthukumaran Packirisamy, BioMEMS Science and Engineering Perspectives, 1st ed., CRC Press, 2011*
6. *Albert Folch, Introduction to BioMEMS, 1st ed., CRC Press, 2013*
7. *Gerald A Urban, BioMEMS, 1st ed., Springer, 2006*
8. *Chang Liu, Foundations of MEMS, 2nd ed., Prentice Hall, 2012*
9. *Abraham P. Lee and James L. Lee, BioMEMS and Biomedical Nanotechnology, Vol. 1, 1st ed., Springer, 2006*
10. *Wanjun Wang & Steven A.Soper, BioMEMS- Technologies and applications, 1st ed., CRC Press, 2007*
11. *Walter Karlen and Krzysztof Iniewski, Mobile Point-of-Care Monitors and Diagnostic Device Design, 1st ed., CRC Press, 2015*
12. *Nam-Trung Nguyen & Steven T Wereley, Fundamentals and Applications of Microfluidics, 2nd ed., Artech House, 2006*
13. *Dongqing Li, Encyclopedia of Microfluidics and Nanofluidics, 1st ed., Springer, 2008*
14. *Chao-Min Cheng, Chen-MengKuan & Chien-Fu Chen, In-Vitro Diagnostic Devices: Introduction to Current Point of Care Diagnostic Devices, 1st ed., Springer, 2016*
15. *Mel L. Mendelson, Learning Bio-Micro-Nanotechnology, 1st ed., CRC Press, 2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	***1. Mr. Karthik Raj V, SRMIST***
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2.* ***Dr. D. Ashok Kumar****, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE267J	Course Name	BIOMECHANICS	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Utilize concepts of kinematics and kinetics of human motion and functioning of bone.
CLR-2 :	Utilize the mechanics of joints, skeletal muscle, elbow and hand
CLR-3 :	Analyze mechanics applied in various movement and loads on shoulder, hip and knee.
CLR-4 :	Analyze movements and loads applied on spine, foot and its effect on human gait.
CLR-5 :	Utilize the fluid medium in human movement and application of sports biomechanics.
CLR-6 :	Understand the concepts of reactive services applied in human movements

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu.
CLO-1 :	Apply principles and concepts of biomechanics in the field of kinematics and kinetics of human motion	3	80	75	M	M	-	-	-	-	-	-	-	-	-	L	L	-	-
CLO-2 :	Identify the basic functionalities of joints, skeletal muscle, elbow and hand.	3	80	70	-	M	-	L	M	-	-	-	-	-	-	L	L	L	-
CLO-3 :	Analyze the functionality and various forces applied on shoulder, hip and knee.	3	75	70	M	M	L	M	M	-	-	-	-	-	-	-	-	L	M
CLO-4 :	Apply various loads on spine and foot to analyze the information on various human gait.	3	80	75	-	-	M	M	M	-	-	-	-	-	-	-	-	L	M
CLO-5 :	Communicate and implement the knowledge in various applications related to human movement	3	80	70	M	M	-	-	-	-	-	-	-	-	-	L	L	-	-
CLO-6 :	Apply rehabilitation services in all biomechanical activities	3	80	70	-	M	-	L	M	-	-	-	-	-	-	L	L	L	-

Duration (hour)		Kinetic and kinematics of human motion and Biomechanics of human bone	Biomechanics of skeletal muscle, Elbow and hand	Biomechanics of Shoulder, hip and knee	Biomechanics of spine and Analysis of gait	Sports Biomechanics
		12	12	12	12	12
S-1	SLO-1	Forms of motion, Spatial reference systems, analysis of human movement	Joint architecture	Structure of the shoulder	Structure of the spine, Spinal curves	Biomechanics in physical education- Qualitative analysis of kicking
	SLO-2	Standard reference terminology, Joint movement terminology	Articular cartilage and connective tissue	Movements of the shoulder	Movements of the spine	Qualitative analysis of batting
S-2	SLO-1	Basic concepts related to kinetics	Joint stability, Joint flexibility	Muscles of the shoulder	Loads on the spine	Human movement in fluid medium- Nature of fluids
	SLO-2	Mechanical loads on the human body, Effects of loading	Techniques for increasing joint Flexibility, Joint injuries	Loads on the shoulder and common injuries of the shoulder	Common injuries of the back and neck	Laminar and turbulent flow and flow properties
S 3-4	SLO-1	Lab 1: Analysis of mechanical stress and strain	Lab 4: Study of joints	Lab 7: 3D modeling of radius and ulna	Lab 10: Segmentation and modeling of lumbar spine	Lab 13: Mini project
	SLO-2					
S-5	SLO-1	Linear and angular kinematic quantities	Structural organization of skeletal muscle-Muscle fibers	Structure of the hip	Gait analysis	Buoyancy
	SLO-2	Relationships between linear and angular motion	Motor units and fiber types	Movements at the hip	Various methods in Gait analysis	Drag and lift force
S-6	SLO-1	Kinematics of projectile motion, Factors influencing Projectile trajectory	Factors affecting muscular force generation	Muscles and loads on the hip	Types of phases	Biomechanics in Strength and conditioning Qualitative analysis of squat technique
	SLO-2	Analyzing projectile motion	Muscular strength, power and endurance	Common injuries of the hip Joint	Measurement approaches and systems for gait	Qualitative analysis of Drop jumps
S 7-8	SLO-1	Lab 2: Projectile motion analysis using MATLAB	Lab 5: Study of Body composition parameters	Lab 8: Segmentation and modeling of femur bone	Lab 11: Analysis of gait	Lab 14: Mini project
	SLO-2					

S-9	**SLO-1**	*Composition and structure of bone tissue*	*Structure of the elbow*	*Structure of the knee*	*Structure of the foot*	*Qualitative analysis of Throwing technique*
	SLO-2	*Bone growth and development*	*Loads on the elbow and common injuries of the elbow*	*Movements at the knee*	*Movements of the foot*	*Qualitative analysis of Dribbling technique*
S-10	**SLO-1**	*Bone response to stress*	*Structure of the joints of the hand*	*Muscles and loads on the knee*	*Loads on the foot*	*Biomechanics in sports medicine and rehabilitation*
	SLO-2	*Osteoporosis*	*Movements of the hand*	*Common injuries of the knee and lower leg*	*Common injuries of foot*	*Dealing with sports injuries*
S 11-12	**SLO-1** **SLO-2**	*Lab 3: Measurement of bone mineral density*	*Lab 6: Segmentation of radius and ulna*	*Lab 9: Segmentation and modeling of fibula and tibia*	*Lab 12: Repeat class*	*Lab 15: Model Exam*

Learning Resources	1. *Susan J Hall, Basic Biomechanics, 4th ed., Tata McGraw hill, 2004* 2. *Duane Knudson, Fundamentals of Biomechanics, 2nd ed., Springer, 2007*	3. *Roger Bartlett, Introduction to Sports Biomechanics: Analysing Human Movement Patterns, 2nd ed., Taylor and Francis, 2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.aniii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Ms. A. Bhargavi Haripriya, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE360T	Course Name	Rehabilitation Engineering	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	To equip the learners to:
CLR-1 :	Learn concepts and terminologies in Rehabilitation Engineering
CLR-2 :	Understand different types of wheel chair design and mobility aids
CLR-3 :	Study the components of orthotic and prosthetic devices and their fabrication
CLR-4 :	Become aware of Engineering concepts in sensory substitution and augmentation
CLR-5 :	Understand the legal concepts in Rehabilitation Engineering
CLR-6 :	Study the contemporary topics in Rehabilitation Engineering

Course Learning Outcomes (CLO):	At the end of this course, learners will Understand design concepts of rehabilitation Engineering and apply the knowledge to augment the well- being of mankind	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Understand the need for rehabilitation Engineering and proficiently use terminologies related to it.	1,2	80	70						M						L	L		
CLO-2 :	Know the various wheel chair design and mobility aid design aspects	1,2	75	65	M		L			L							L	L	
CLO-3 :	Learn about orthotic and prosthetic devices, their design and types.	2	70	65	L		L				L						L		
CLO-4 :	List the various possibilities to augment or substitute visual and auditory capabilities	2,3	70	65	M	M	L			L								L	
CLO-5 :	Describe the legal concepts in Rehabilitation Engineering	3	80	65						M	M								L
CLO-6 :	Gain exposure to the latest topics in Rehabilitation Engineering	3	80	65	M	L	L	M		L							L	M	L

Duration (hour)		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
		9	9	9	9	9
S-1	SLO-1	Introduce to Rehabilitation Engineering and Assistive technologies	Interventions in seating system	Amputation: Definition, need, situations where it can be avoided	Basic structure of eye, How it functions, problems that can be faced	Application of robots in rehabilitation
	SLO-2	Learn Concepts of Rehabilitation Engineering	Wheel Chairs-Introduction	Classification of amputation	Categories of visual impairment, identification of level of intervention needed	Types of robots used
S-2	SLO-1	Learn Terminologies Rehabilitation Engineering	Types of Wheelchairs	Prosthetics: Definition, Need for prosthesis	Artificial Eye-Complete replacement	Challenges in robot design for differently abled people
	SLO-2	***Considerations for Rehabilitation Engineering***	Describe on Manual wheelchairs	Use of prosthesis, Where prosthesis can't be used	***Retinal implant***	***Differences in material used***
S-3	SLO-1	Various approaches for Rehabilitation engineering	Component Design	Basic types of prosthesis, Prosthesis Prescription	Sensory augmentation for blind	Functional electrical stimulation definition,
	SLO-2	PAD process	Electrical Power wheel chairs	Prosthesis for shoulder, neck, torso	Cortical prosthesis	Circuit for stimulations
S-4	SLO-1	PHAATE model	Power assisted wheelchair-Design	Prosthesis for elbow, arm	Assist devices for visual rehabilitation	Significance of myoelecticl signal
	SLO-2	Universal design- Introduction	Design types	Fabrication and issues involved	Auditory devices	Acquisition of myoelecticl signal, challenges
S-5	SLO-1	Seven Principles of Universal design	Wheelchair transportation	Parts of Lower extremity	Devices for navigation, Design of navigation device	Activities of daily living

	SLO-2	*Benefits of Universal design*	*Lift Mechanism*	*Significance of each part, Different movements involved*	*Tactual sensory substitution, Applications and examples of tactual substitution in real life*	*Low tech and hi tech aids in daily living*
S-6	**SLO-1**	*Universal design Matrix*	*Wheelchair safety*	*Prosthesis for knee, hip*	*Main part of ear, Measurement of hearing*	*Neural engineering*
	SLO-2	*Design based on human ability*	*Wheelchair standards and tests*	*Material used for fabrication, examples of available prosthesis*	*Problems that can arise, Range of hearing*	*Implementation in rehabilitation*
S-7	**SLO-1**	*Standards for assistive technology-National and International*	*Intelligent Mobility aids*	*Orthosis: Definition, Difference between orthosis and prosthesis*	*Surgical hearing aids*	*Behavioural disorders and its types*
	SLO-2	*Role of Rehabilitation Engineering in standards development*	*Smart wheeled walkers*	*Orthosis for shoulder, neck*	*Cochlear and eardrum interventions*	*Rehabilitation methods involves*
S-8	**SLO-1**	*Rehabilitation Engineering and its research opportunities*	*All terrain wheelchair*	*Orthosis for foot, Material used: the problems faced with the material*	*Non surgical hearing aids*	*Sports rehabilitation*
	SLO-2	*Future of Engineering in Rehabilitation*	*Current directions in wheelchair research*	*Components of lower limp prosthesis*	*Design of a simple external hearing aid*	*Measurement technology for sports mechanics*
S-9	**SLO-1**	*Seating and common pathologies*	*Parts of Upper extremity*	*External circuitry design and support system*	*Sign language*	*Legal aspect in rehabilitation*
	SLO-2	*Seating assessment*	*Significance of each part, Different movements involved*	*Indentifying the orthosis and prosthesis which can be used* *Practice session: student to indentify the area of amputation and what to use in that location*	*Devices for sign language translation*	*Provision for rehabilitation*

Learning Resources	5. *Rory A Cooper, Hisaichi Ohnabe, Duglas A Hodson, "An Introduction to Rehabilitation Engineering", CRC Press, First edition, 2006* 6. *Rory A Cooper, "Rehabilitation Engineering Applied to Mobility and Manipulation", CRC Press, First edition, 2010* 7. *Horia-Nicolai.L. Teodorescu, Lakhsmi.C. Jain, "Intelligent Systems and Technologies in Rehabilitaion Engineering", CRC Press, First Edition, 2010.*	8. *Marion A Hersh, Michale A Johnson, "Assistive Technology fo Visually impaired and blind people", Springers Publications, First edition 2008.* 9. *Suzanne Robitaille, "The illustrated guide to Assistive technology and devices-Tools and gadgets for living independently", Demos Health Newyork, First edition, 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai,* venkat@niot.res.in	

Course Code	18ECE361T	Course Name	BIOMEDICAL NANOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Learn the different synthesis method and its application
CLR-2 :	Apply the various characterization techniques in nano materials
CLR-3 :	Comprehend the principles behind nanomedicine
CLR-4 :	Gain a broad understanding of concepts and applications of nanomedicine
CLR-5 :	Apply concepts of nanomedicine to a focused clinical area of their choice
CLR-6 :	Acquire knowledge to apply these nanosystems for the diagnosis and therapy.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO-1: Problem Solving at the interface of Engg. & Medicine	PLO 14 PSO.-2: Design & Develop Medical Devices	PLO 15 PSO-3: multidisciplinary research for health care solu
CLO-1 :	Analyze the suitable method in biomedical application	3	80	75	M	-	-	L	-	-	-	-	-	-	-	-	L	-	L
CLO-2 :	Identify the various characterization techniques in nano materials	3	80	70	L	-	-	L	-	-	-	-	-	-	-	-	L	-	L
CLO-3 :	Describe the properties and techniques in nano biomaterials	3	75	70	L	-	-	L	-	-	-	-	-	-	-	-	L	-	L
CLO-4 :	Analyze the concept of nano therapeutics and application in biomedical	3	80	75	M	-	-	M	-	-	-	-	-	-	-	-	L	-	L
CLO-5 :	Identify the principle behind modern bio nano imaging techniques	3	80	70	M	-	-	M	-	-	-	-	-	-	-	-	L	-	L
CLO-6 :	Apply the nano materials in 3D printing techniques	3	80	70	M	-	-	M	-	-	-	-	-	-	-	-	L	-	L

Duration (hour)		Synthesis of nano material	Nano materials characterization techniques	Nano biomaterials	Nano therapeutic	Nano biomedical imaging and 3D Bio printing techniques
		9	9	9	9	9
S-1	SLO-1	Introduction About Nano technology	Introduction to Scanning electron microscope(SEM)	Introduction to nano biomaterials	Drug to delivery to central nervous system	Introduction to biomedical imaging
	SLO-2	Bulk synthesis:	Application of scanning electron microscope	Surface and bulk properties of biomaterials	Drug delivery across blood brain barrier	The emergence of nanoparticle as imaging platform in medicine
S-2	SLO-1	Top down and bottom approaches	Energy dispersive spectroscopy (EDS)	Nano biomaterials, Nano bio ceramics	Nano wire monitoring the brain activity	Magnetic resonance imaging basics
	SLO-2	***Physical vapour deposition methods***	Basics principle of atomic microscopy	Hydroxyapatite ant its properties	***Introduction to Nano robot medical device***	***MRI working ,paramagnetic contrast agents***
S-3	SLO-1	Electron beam evaporation techniques	Construction, working and application of atomic microscopy	Hydroxyapatite ant its applications	Application of ***Nano robot medical device***	Magnetic Nano sensor
	SLO-2	Pulsed laser deposition	Introduction to transmission electron microscopy	Alumina and its properties ,application	Introduction to nano drug carrier	Radio labeled nano particles.
S-4	SLO-1	Sputtering techniques	Application of transmission electron microscopy	Zirconia and Titania and its properties	Nano carrier for ocular drug delivery	Sound waves nano particle
	SLO-2	Evaporation techniques	Scanning probe microscope	Zirconia and Titania ant its applications	cell therapy for myocardial infection	Application in ultra sound imaging

S-5	**SLO-1**	*Cathodic arc deposition*	*Nano indentation techniques*	*Nano diamond carbon nano materials*	*Types of cell therapy for myocardial infection*	*Biological imaging*
	SLO-2	*Spin coating unit, spray pyrolysis*	*Cantilever array sensor*	*Nano diamond carbon materials and its applications.*	*Nano neurosurgery,*	*Quantum dot in optical imaging*
S-6	**SLO-1**	*Chemical vapor deposition(CVD)*	*Basics principle of scanning tunneling microscopy*	*Introduction to surface modification*	*nanolipoblockers*	*3D printing*
	SLO-2	*Types of chemical vapour deposition*	*Constriction and application of scanning tunneling microscope(STM)*	*Types of surface modification method*	*Antirestenosis drugs*	*Introduction and principle*
S-7	**SLO-1**	*Plasma method: Plasma enhanced CVD*	*Introduction about X-ray diffraction*	*Textured and porous materials*	*Introduction to nano particle drug formulations*	*3D printing technology :ink let based*
	SLO-2	*Hot filament CVD*	*Measurement and application of XRD*	*Cell biomaterials interactions*	*nano particle drug formulations for spray inhalations*	*Pressure assisted, laser assisted*
S-8	**SLO-1**	*Chemical synthesis: Sol gel processing*	*X-ray photon spectroscopy(XPS)*	*Immune response*	*Introduction to nano bone implants*	*Solenoid valve based, acoustic jet based*
	SLO-2	*hydrothermal,co precipitation,*	*Application XPS*	*Bone Scaffold preparations*	*Nano bone implants and scaffolds*	*3D bio printing in ceramics ,polymers*
S-9	**SLO-1**	*Wet chemical method*	*Electrochemical work station*	*Scaffold properties and its applications*	*Introduction to nano technology in cardio vascular system*	*3D bio printing in organs*
	SLO-2	*Hydrolysis ,Electrophoretic deposition*	*Application of electrochemical work station*	*In vitro and in vivo tissue biocompatibility*	*Regeneration of cardiovascular system*	*Challenge and future development of 3D bio printing*

Learning Resources	1. *Khandpur R.S, Hand-book of Biomedical Instrumentation, 2nd ed., Tata McGraw Hill, 2003* 2. *Michael Giersig, Gennady B. Khomutov,"Nanomaterials for Application in Medicine and Biology", Springer, 2008* 3. *Jeff W.M., Bulte and Michel M.J. Modo "Nanoparticles in Biomedical Imaging Emerging Technologies and Applications", Springer, 2010*	4. *Guozhong Cao, "Nanostructures and Nanomaterials, synthesis, properties and applications", Imperial College Press, 2004* 5. *C. N. Rao, A. Muller, A. K. Cheetham "The Chemistry of Nanomaterials: Synthesis, Properties and Applications", Wiley, 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	*1. Mr. S. Gnanavel, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr. D. Ashok Kumar, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE362T	Course Name	Physiological Modeling and simulation	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses		Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Build an engineering model based on physiological subsystems			
CLR-2 :	Implement static analysis for physiological systems			
CLR-3 :	Understand time domain and stability analysis of physiological systems			
CLR-4 :	Implement frequency response analysis for physiological systems			
CLR-5 :	Identify and estimate unknown parameters in system modeling			
CLR-6 :	Represent the working of physiological systems using different modeling techniques			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Develop a more in-depth level of understanding engineering analysis for modeling physiological systems	1,2	80	70
CLO-2 :	Perform static analysis of a system	1,2	80	70
CLO-3 :	Perform transient and stability analysis of a system.	1,2	80	70
CLO-4 :	Able to do frequency analysis of the system	1,2	80	70
CLO-5 :	Understand and implement system identification techniques	1,2	80	70
CLO-6 :	Implement the various mathematical modeling techniques to physiological systems	1,2	80	70

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO.-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	M	-	-	-	-	-	-	-	-	-	-	-	M		
CLO-2 :	-	M	-	-	-	-	-	-	-	-	-	-	M		
CLO-3 :	-	M	-	-	-	-	-	-	-	-	-	-	M		
CLO-4 :	-	M	-	-	-	-	-	-	-	-	-	-	M		
CLO-5 :	-	L	-	-	-	-	-	-	-	-	-	-	M		
CLO-6 :	M		-	-	-	-	-	-	-	-	-	-	M		

Duration (hour)		Linear Model	Static Analysis	Time Domain Analysis	Frequency Domain Analysis	System Identification
		9	9	9	9	9
S-1	SLO-1	Introduction to modeling methodology, need for models, approaches to modeling	Static analysis: Open loop versus closed loop	Introduction to time domain analysis	Frequency response: Open loop frequency response	Identification of physiological control system
	SLO-2	Model identification, model validation and Simulation	Loop gain calculation: Room temperature control	Linearized respiratory mechanics transient response	Closed loop frequency response	Basic problems in Physiological system analysis
S-2	SLO-1	System analysis, fundamental concepts	Steady state characteristics	Linearized respiratory mechanics first order model – impulse response for open loop	Relation between transient and frequency response	Nonparametric and parametric identification methods
	SLO-2	Physiological control system an example	Determination of steady state operating point for simple model of muscle stretch reflex	Linearized respiratory mechanics first order model – impulse response for closed loop	Frequency domain specifications	Numerical Deconvolution, Least square estimation
S-3	SLO-1	Engineering control system versus physiological control system	Human body Glucose – Insulin regulatory system	Transient response descriptors : Impulse response	Graphical representation of frequency response: Bode plot	Estimation using correlation functions
	SLO-2	Science of modeling	Steady state analysis of glucose –insulin model	Transient response descriptors : Step response	Bode plot :Linearized lung mechanics	Estimation in frequency domain, optimization techniques
S-4	SLO-1	Generalized system properties	Human body chemical regulation of ventilatory system	Concept of sliding theory	Graphical representation of frequency response: Nicholas chart	Problems in parameter estimation
	SLO-2	Models with combinations of system elements	Mechanism of respiration	Neuromuscular reflex action	Nicholas chart : Linearized lung mechanics	Input design
S-5	SLO-1	Linear model of respiratory mechanics	Gas exchanger mathematical modeling	Mathematical model of neuromuscular reflex motion	Graphical representation of frequency response : Nyquist plot	Identification of closed loop systems – "opening the loop"
	SLO-2	Linear model of respiratory mechanics: Derivation of transfer function	Respiratory controller mathematical modeling	Calculation of transfer function	Nyquist plot: Linearized lung mechanics	Starling heart- lung preparation

S-6	**SLO-1**	*Linear model of muscle mechanics*	*Closed loop analysis : lung and controller*	*Stability and transient response*	*Introduction : Circulatory system*	*Kao's cross – circulation experiment*
	SLO-2	*Linear model of muscle mechanics: Derivation of transfer function*	*Calculation of transfer function*	*Root locus and Routh-Hurwitz stability criterion*	*Mathematical model of circulatory system*	*Artificial brain perfusion for partitioning central and chemo reflexes*
S-7	**SLO-1**	*Distributed versus lumped parameter model*	*Heart and systemic circulation*	*Stability analysis: root locus method*	*Frequency response of circulatory system*	*Voltage clamp*
	SLO-2	*Distributed versus lumped parameter model: Derivation of transfer function*	*Mathematical modeling of cardiac output*	*Introduction to Nyquist plot*	*Graphical representation for frequency response of circulatory system*	*Opening the Pupillary reflex loop, Read rebreathing technique*
S-8	**SLO-1**	*Linear system and superposition principle*	*Calculation of transfer function for simplified model of cardiac output regulation*	*Nyquist criterion for stability*	*Frequency response of glucose – insulin model*	*Identification under closed loop condition*
	SLO-2	*Laplace transform and transfer function*	*Cardiac characteristics curve analysis*	*Relative stability theory*	*Mathematical model and simulation of glucose – insulin model*	*Minimal model of blood glucose regulation*
S-9	**SLO-1**	*Impulse function analysis*	*Venous return curve*	*Physiology: Pupillary reflex control*	*Frequency response approach to pupil control*	*Optimization : Introduction*
	SLO-2	*Basics of Linear convolution*	*Closed loop analysis of heart and systemic circulation*	*Mathematical modeling and stability analysis of pupillary reflex control*	*Frequency response characteristics curve for pupillary control*	*Optimization in systems with negative feedback*

Learning Resources

1. *Michael C.K. Khoo, "Physiological Control Systems - Analysis, Simulation and Estimation", Prentice Hall of India Private Ltd., 2nd edition, New Delhi, 2001.*
2. *V.Z. Marmarelis,"Advanced Methods of Physiological System Modeling", Vol.3, Springer Science and Business Media, 2013.*
3. *Claudio Cobelli Ewart Carson, , "Introduction to Modeling in Physiology and Medicine", Academic press series, 1st edition, 2008.*
4. *Johnny T. Ottesen, Mette S. Olufsen, Jesper K. Larsen, "Applied Mathematical Models in Human Physiology", Vol.9,SIAM, 2004.*
5. *Dorf, "Modern Control Systems",Pearson Education India, 1st edition, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	15EC363J	Course Name	MEDICAL IMAGE PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. &	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu.
CLR-1 :	Understand the fundamental image operations and image transforms																		
CLR-2 :	Apply various image enhancement techniques in enhancing the medial images																		
CLR-3 :	Analyze the various types of image segmentation algorithms																		
CLR-4 :	Gain knowledge in Image compression and image registration methods																		
CLR-5 :	Understand the image reconstruction techniques used in reconstruction of medical images																		
CLR-6 :	The learner gains knowledge in Image retrieval and digital image watermarking																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Describe the 2D Sampling theory and different types of image transforms	1, 2	80	70	M														
CLO-2 :	Implement the image enhancement techniques for improving the quality of medical images	2	80	70	M														
CLO-3 :	Apply the different image segmentation algorithms for various medical applications	2	80	70			M		M								M		L
CLO-4 :	Differentiate and analyze the various image compression and registration algorithms	3	80	70					M										
CLO-5 :	Analyze the various image reconstruction methods used for medical images	3	80	70	M												M		L
CLO-6 :	Illustrate the concepts of wavelet transform and digital image water marking	3	80	70	M														

Duration (hour)		Fundamental Image Operations and Transforms	Image Enhancement methods	Image Segmentation Algorithms	Image compression and image registration methods	Image Reconstruction Methods
		12	12	12	12	12
S-1	SLO-1	Elements of Visual Perception- structure of human eye and image formation	Basic gray level transformation- image negative, intensity slicing techniques	Morphological operations-Erosion	Image compression-Introduction	Image reconstruction from projections- Radon transform- derivation
	SLO-2	Brightness range adaptation and discrimination	Contrast stretching, dynamic range compression and bit plane slicing	Dilation	Types of redundancies	Properties
S-2	SLO-1	Image sampling-2D sampling Theory	Histogram equalization	Image opening	Huffman coding technique	Inverse radon transform- convolution back projection
	SLO-2	Reconstruction from its samples	Histogram specification	Image closing	Procedure	Filter back projection
S-3,4	SLO-1	Lab1: Basic operations on images	Lab4: Gray transformation and histogram equalization	Lab 7: Morphological operations	Lab 10: Image compression	Lab 13: Image reconstruction from projection data
	SLO-2					
S-5	SLO-1	Quantization- optimal mean square quantizer	Image smoothening in spatial domain – Low pass filter	Edge detection- Marr hildreth edge detector	Image registration- Introduction	Digital implementation of filter back projection- Block diagram
	SLO-2	Uniform quantizer	Median filter	Algorithm	Dimensionality transformation	Algorithm
S-6	SLO-1	Neighborhood pixel relationships- adjacencies	Image sharpening in spatial domain – High pass filter, high boost filter	Canny edge detection- smoothing	Rigid registration algorithm	Wavelet transform-Introduction
	SLO-2	Distance measures	Derivative filters	Non maxima suppression and thresholding	Rigid registration algorithm	Algorithm

S-7,8	**SLO-1**	*Lab2: Image transforms in spatial domain*	*Lab 5: Image smoothening using suitable filters*	*Lab 8: Edge detection techniques*	*Lab 11: Image registration*	*Lab 14: Wavelet transform*
	SLO-2					
S-9	**SLO-1**	*Image transform –DFT, DCT*	*Image smoothening in frequency domain*	*Thresholding –basics*	*Registration of MRI and PET images*	*Digital image watermarking-Introduction*
	SLO-2	*Properties*	*Image sharpening in frequency domain*	*Global thresholding algorithm*	*Clinical applications*	*Applications*
S-10	**SLO-1**	*Haar Transform*	*Color image processing-Introduction*	*Region based segmentation-region growing algorithm*	*Registration of MRI and CT images*	*Image retrieval-Introduction*
	SLO-2	*Properties*	*Color models*	*Region splitting and merging algorithm*	*Clinical applications*	*Content based image retrieval*
S-11,12	**SLO-1**	*Lab3: Image transforms in frequency domain*	*Lab 6: Image sharpening using suitable filters*	*Lab9: Image segmentation using Thresholding*	*Lab 12: Fusion of MRI and CT images*	*Lab 15: Digital image watermarking*
	SLO-2					

Learning Resources	3. *Rafael C., Gonzalez and Richard E. Woods,"Digital Image Processing", Pearson Education Asia, Third Edition, 2007* 4. *Anil.k.Jain, "Fundamentals of Digital image processing", Prentice Hall of India, 2nd edition 1997.*	5. *Joseph V.Hajnal, Derek L.G.Hill, David J Hawkes, "Medical image registration", Biomedical Engineering series, CRC press,2001.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai,* venkat@niot.res.in	

Course Code	18ECE364T	Course Name	Body Area Network and Mobile Healthcare	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of the learning this course is to provide an overview of the technical background of Body Area Networks (**BAN**) and its application in health care using mobile technology
CLR-1 :	Comprehend technical information and challenges in **WBAN**.
CLR-2 :	Describe the hardware requirements of **BAN**
CLR-3 :	Review the wearable sensors and standards for **BAN**
CLR-4 :	Describe the mobile devices that is available for health care
CLR-5 :	Summarize the possible and latest applications of mobile healthcare
CLR-6 :	Learn about context-aware health care applications

Course Learning Outcomes (CLO):	At the end of this course, learns will be able to :	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	List out the BAN challenges	1	80	75
CLO-2 :	Identify the hardware necessary for BAN	1	80	75
CLO-3 :	List and describe the various wearable sensors	1,2	80	75
CLO-4 :	Appreciate the mobile devices available for healthcare	1.2	80	75
CLO-5 :	List the latest applications and research opportunities with mobile healthcare.	2	80	75
CLO-6 :	Think about context-aware health care solutions	3	80	75

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engn. & Medicine	PSO.-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :		L													
CLO-2 :	L														
CLO-3 :		L											L		
CLO-4 :	L														
CLO-5 :														L	
CLO-6 :															M

Duration (hour)		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
		9	9	9	9	9
S-1	SLO-1	***BAN*-Definition**	*Processor in BAN*	*RF communication*	*Sensors for wearable system*	*Mobile health technologies*
	SLO-2	*Terminologies used with **BAN***	*Low Power MCUs*	*RF communication in and around the body*	*Wearable system design for specific applications*	*Mobile nutrition tracking*
S-2	SLO-1	*Technical Challenges*	*Mobile Computing MCU*	*Antennal Design*	*Wearable system for ECG monitoring,*	*Accessing existing virtual electronic patient record*
	SLO-2	*Sensor design concepts*	*Integrated processor*	*Antenna testing*	*Wearable system for EEG monitoring,*	*Mobile personal health records,*
S-3	SLO-1	*Types of sensors*	*Radio transceiver along with the processor*	*Propagation issues*	*Wearable system for Gait analysis*	*Monitoring hospital patients,*
	SLO-2	*Biocompatibility issues*	*Integrated processor with Memory*	*Base Station considerations*	*Evaluation of general performance*	*Sensing vital signs*
S-4	SLO-1	*Energy Requirements*	*Antenna for BAN*	*Network topology*	*Evaluation of night time performance*	*Transmission using wireless networks*
	SLO-2	*Energy supply*	*Antenna Requirements*	*Stand – Alone BAN*	*Evaluation parameters*	*Continuous monitoring*
S-5	SLO-1	*Nodes, number of node*	*Antenna Considerations*	*Wireless personal Area Network*	*Latest health monitoring methods*	*Patient Monitoring and wearable devices*

	SLO-2	*Optimal node placement in **BAN***	*Types of antenna*	*Wireless personal Area Network Technologies*	*Smart phone based health care monitoring system*	*Patient Monitoring in Diverse Environments*
S-6	**SLO-1**	*System security*	*Wire antenna*	*IEEE 802.15.1*	*Phone based fall risk prediction*	*A framework for Capturing Patient Consent in Pervasive Healthcare Applications*
	SLO-2	*System Reliability*	*Ceramic antenna*	*IEEE P802.15.13*	*Emergency alerts*	*M-health application*
S-7	**SLO-1**	***BAN** Standards*	*External antenna*	*IEEE 702.15.14*	*RFID based personal mobile medical assistance*	*Context aware sensing*
	SLO-2	***BAN** with other standards*	*Sensor Interface*	*Zigbee*	*Other similar technologies*	*Technology Enablers for context-Aware healthcare Applications*
S-8	**SLO-1**	***BAN** Architecture*	*Considerations on the interface*	***BAN** and **WBAN** technologies*	*Infusing image processing capabilities*	*Case study I*
	SLO-2	***BAN** and other technologies*	*Power sources- Batteries*	*Limitations in use*	*Secure medical sensor network with HIP*	*Case study I*
S-9	**SLO-1**	***BAN** and Healthcare*	*Fuel cells for sensor nodes.*	*Coexistence issues with **BAN***	*Diagnostic applications*	*Case study II*
	SLO-2	*Medical Applications of **BAN***	*Other novel power sources*	*Other practical considerations*	*Therapeutic applications*	*Case study II*

Learning Resources

1. *Annalisa Bonfiglio, Danilo De Rossi, " Wearable Monitoring Systems", Springer, 2011.*
2. *Philip Olla, Josep Tan, " Mobile Health solutions for Biomedical applications", Medical Information science reference, Hershey New York, **IGI Global 2009.***
3. *Zhang, Yuan-Ting, Wearable Medical Sensors and systems, Sringers, 2013.*
4. *Guang-Zhogn Yang(ED), " Body Sensor Networks", Springers, 2013*
5. ***Mehmet R. Yuce Jamil Y.Khan, " Wireless Body Area Networks Technology, Implementation and applications", Pan Standford Pte. Ltd., Singapore, 2012***
6. ***Konstantina, James C. Lin, Dimitrios, Maria Teresa, " Wireless mobile communication and healthcare", Secon International ICST conference, Mobihealth 2011, Springers 2011.***
7. ***Ullah, Sana, Et at, " A review of wireless body area networks for medical applications", arXiv: 1001.083, 2010***
8. ***Patel, Shyamal, Et al, " A review of wearable sensors and systems with application in rehabilitation", Neuroeng Rehabil 9.12, 2012, 1-17.***

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Code	18ECE365T	Course Name	Bio-inspired Human Machine Interface	Course Category	E	Professional Electives	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Study the HMI design, principles and standards
CLR-2 :	Attain knowledge in optic and acoustic based HMI design
CLR-3 :	Acquire knowledge in Bioelectric interfaces
CLR-4 :	Study the brain signal based HMI design
CLR-5 :	Have an insight knowledge in advanced HMI design

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Explain the basics, rules and generic design flow of HMI systems	3	80	75
CLO-2 :	Explain and analyze the optic and Acoustic based HMI systems	3	80	70
CLO-3 :	Analyze and discuss the bioelectric based HMI design	3	75	70
CLO-4 :	Explain and analyze brain signal based HMI design	3	80	75
CLO-5 :	Analyze and discuss the advances and challenges in HMI design	3	80	70
CLO-6:	Design a biomimetic system for neural prosthesis	3	80	75

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg.	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care
M	M			L										
M	M			L										
M	M			L										
M	M			L										
M	M			L										
M	M			L										

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to HMI	Vision based HMI design-Introduction-	Bioelectric Interfaces-Introduction	Brain Computer Interfaces-Introduction	Affective Computing based HMI-Introduction
	SLO-2	Need for HMI systems	Face Recognition-Signal Acquisition	Myoelectric interfaces-Introduction	brain regions and responsibilities	Affective Computing based HMI-Data Acquisition
S-2	SLO-1	Types of HMI	Face Recognition-Data Analysis	Muscle regions and responsibilities	Active methods for measuring brain activity	Affective Computing based HMI-Data Classification
	SLO-2	Types of HMI	Vision based HMI design-Data Classification	Methods for measuring muscle activity	Active methods for measuring brain activity(Contd.)	Application of Affective Computing based HMI
S-3	SLO-1	HMI-guidelines	Gait Recognition-Signal Acquisition	Myoelectric Signal –Data Analysis	Invasive BCI	Wearable Computing-Introduction
	SLO-2	HMI-principles	Gait Recognition-Data Analysis & Classification	Myoelectric Signal –Data Analysis(Contd.)	Non-invasive BCI	Wearable Computing
S-4	SLO-1	HMI-standards	Gesture Recognition-Data Analysis &Classification	Myoelectric Signal –Data Classification	EEG based BCI	Tactile based HMI
	SLO-2	HMI-Ethical Issues	People tracking	Application of Myoelectric HMI	P300 based BCI	Tactile based HMI
S-5	SLO-1	Interaction design-basics	LED based HMI system	ECG based HMI design	VEP based BCI	Motion based HMI
	SLO-2	Interaction design-Design rules	LASER based HMI system	ECG based HMI design(Contd.)	NIRS based BCI	Motion based HMI
S-6	SLO-1	HMI Systems-Data Collection	Speech Communication	EOG based HMI design-Introduction	Application in Prosthetic Control	Biomimetic design of neural prosthesis
	SLO-2	HMI Systems-Data Analysis	Speech Communication (Contd.)	EOG based HMI design-Signal Acquisition	Application in Prosthetic Control	Biomimetic design of neural prosthesis
S-7	SLO-1	HMI Systems-Design	Fundamentals of Speech Recognition	EOG based HMI design-Signal Analysis	Neurorehabilitation	Intracranial human machine interfaces for communication and control

	SLO-2	*HMI Systems-Prototyping*	*Fundamentals of Speech Recognition(Contd.)*	*EOG based HMI design-Signal Analysis(Contd.)*	*Neurorehabilitation*	*Intracranial human machine interfaces for communication and control*
S-8	**SLO-1**	*Evaluation of HMI Systems*	*Automatic Speech Recognition*	*EOG based HMI design-Signal Classification*	*Neuromarketing*	*Multimodal approaches for advanced HMI design*
	SLO-2	*Evaluation of HMI Systems*	*Automatic Speech Recognition(Contd.)*	*EOG based HMI design-Signal Classification(Contd.)*	*Neuromarketing*	*Multimodal approaches for advanced HMI design*
S-9	**SLO-1**	*Bio-inspired HMI Systems*	*Multimodal Interaction &Approaches*	*Applications of EOG based HMI*	*Brain controlled wheel chairs*	*Multimodal approaches for advanced HMI design*
	SLO-2	*Bio-inspired HMI Systems*	*Multimodal Interaction &Approaches (Contd.)*	*Applications of EOG based HMI (Contd.)*	*Brain controlled wheel chairs*	*Multimodal approaches for advanced HMI design*

Learning Resources	1. Yvonne Rogers, Helen Sharp, Jenny Preece, "Interaction Design: Beyond Human Computer Interaction", 3rd Edition, Willey Publisher, 2012. 2. P C Yuen, Y Y Tang , P S P Wang, "Multimodal Interface For Human-Machine Communication", World Scientific, 2002. 3. Aboul-Ella Hassanien and Ahmad Taher Azar, "Brain-Computer Interfaces:Current Trends and Applications", Springer International Publishing AG, 2016.	4. Rajesh P. N. Rao, "Brain-Computer Interfacing : An Introduction", Cambridge University Press, 2013 5. Masaki Kurosu, Human-Computer Interaction. User Interface Design, Development and Multimodality, Springer International Publishing AG, 2017

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	*1. Dr.Hariharan, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University,* meena68@annauniv.edu	*2. Dr.U.Snekhalatha, SRMIST*
. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai,* venkat@niot.res.in	

Course Code	18ECE366T	Course Name	Implantable Bioelectronics	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EES101J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to provide a cognizance of striking a balance between electronics and biomedical engineering	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Comprehend technical information about miniaturized Implantable Biomedical devices			
CLR-2 :	Introduce to neural interfaces and cyborgs			
CLR-3 :	Know about implantable user interface and CMOS imaging systems			
CLR-4 :	Learn about implantable electronics biocompatibility criteria and telemetry			
CLR-5 :	Know the key design trends in implantable systems			
CLR-6 :	Know the future of Biomedical Implantable systems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. &	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Describe the design of Implantable Biomedical Devices	1,2	80	75	M														
CLO-2 :	Tell about neural interfaces and cyborgs	1	80	75	L														
CLO-3 :	Describe about implantable user interface and CMOS imaging systems	1,2	80	75	M														
CLO-4 :	Tell about implantable electronics biocompatibility criteria and telemetry	1	80	75						L	L								
CLO-5 :	Consolidate on design trends in implantable systems	2,3	80	75	L													L	
CLO-6 :	Summarize the future of Biomedical Implantable systems	2,3	80	75														L	

Duration (hour)		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
		9	9	9	9	9
S-1	SLO-1	Bioelectronics-Introduction	Neural interfaces and cyborgs- introduction	Implantable user interfaces	Biotelemtry	Design trends in Biomedical Implantable systems
	SLO-2	Energy Harvesting as a Pathway to miniaturization,	Fusing Robotics with the Human Body	Design Considerations	Inductive Link for Forward Data	Design of Implant Systems-
S-2	SLO-1	Implantable Devices	Anatomy of Peripheral Nerves	Evaluating Basic Implanted User Interfaces	Wireless Power Link	Review-History
	SLO-2	***Implementation of Implantable Devices***	Interfacing with the periphery for recording and stimulation	Qualitative Evaluation,	***Implantable device with external units***	***Basic Considerations and Characteristics of RF MEMS Implantable Systems-***
S-3	SLO-1	RF Power Harvesting	Listening to the Brain	Medical Considerations	Implantable Telemetry Link	Legal Considerations of the Radio Frequency (RF)
	SLO-2	Matching network, rectifier,	Interfacing with the Central Nervous System	Limitations	Wideband telemetry links	Field Strength
S-4	SLO-1	Regulator and band gap reference	Eletrical Modulation of the Human Nervous System	CMOS Imaging Devices	Multichannel neural recording systems	Power Levels
	SLO-2	Implant functional block	Pain Modulation	Fundamentals of CMOS Imaging	Wireless endoscope	Biocompatibility
S-5	SLO-1	Wireless Communication Link,	Electrical Modulation of Inflammation	Photo sensors,	Microelectrode Arrays	Protection of the Biomedical Implant

	SLO-2	*Forward and reserve data link*	*Cyborgs*	*Log sensors*	*Interface Electronics*	*Systems-Characteristics of Biological and Medical Signals*
S-6	**SLO-1**	*Payload*	*The Neuro-Tech Version*	*SPAD sensors*	*Electrode equivalent circuit*	*Design considerations of Implantable Systems, Micro power Electronic Design*
	SLO-2	*Applications*	*Biological Brains in a Robot Body*	*Artificial Retina*	*Stimulation Front Ends*	*Approaches*
S-7	**SLO-1**	*Locomotive Implant*	*Deep Brain Stimulation*	*Principle of Artificial Retina*	*Recording Front-Ends*	*Samples*
	SLO-2	*Implantable Cardiac Probe,*	*General Purpose Brain Implants*	*Artificial Retina Based on CMOS Imaging Device*	*Instrumentation amplifier*	*Power Supply design.*
S-8	**SLO-1**	*Communication power delivery*	*Brain-Computer Interfaces*	*Brain-Implantable CMOS Imaging Device*	*Improving the Biocompatibility of Implantable Bioelectronics Devices.*	*System integration*
	SLO-2	*System Overview of a Generic Bioelectronics Implant*	*Noninvasive Brain-Computer Interfaces*	*Measurement Methods for Brain Activities*	*Implantable Bioelectronics Devices Materials*	*Micro-Packages,*
S-9	**SLO-1**	*Circuit Design for Low-Power Signal Processing.*	*Sub dermal Magnetic Implants*	*Fiber Endoscope and Head-Mountable Device*	*Surface Composition*	*Present Challenges,*
	SLO-2	*Architecture-Level Optimization for Low-Power Data Processing*	*RF ID Implants.*	*Summary and future directions*	*Response to Implantation*	*Nano-Enabled Implantable Device for In Vivo Glucose Monitoring*

Learning Resources	*1. Evgeny Katz, "Implantable Biolectronics Devices materials and Applications", Wiley-VCH, 2014.* *2. Vinod Kumar Khanna, "Implantable Medical Electronics Prosthetics, Drug Delivery and Health Monitoring", Springer, 2016*	*3. Swarup Bhunia, Steve Majerus, Mohamad Sawan, Implantable Biomedical Microsystems: Design Principles and Applications", Elsevier, 2015.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University,* meena68@annauniv.edu	*Mr.Karthik Raj, SRMIST*
. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai,* venkat@niot.res.in	

Course Code	18ECE367T	Course Name	TROUBLESHOOTING AND REGULATORY AFFAIRS IN MEDICAL INSTRUMENTS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC201J, 18ECE260J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the fundamental troubleshooting procedures and testing of basic electronic components			
CLR-2 :	Get an idea about the fault diagnosis in analog circuits and digital ICs.			
CLR-3 :	Acquire an idea about the basic troubleshooting procedures for biomedical equipment			
CLR-4 :	Get an idea about the medical device classification globally and regulatory standards			
CLR-5 :	Get an idea about the Indian perspective medical device regulatory system			
CLR-6 :	Get an overall idea about the importance of troubleshooting and medical device classification in India			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. &	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Apply the common troubleshooting procedures in Electronic Equipment and Outline the testing procedures of active and passive components	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Analyze the faults in analog circuits and digital ICs	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Identify the problems in common biomedical equipment in hospitals when it is not working and provide a suitable solution	2	80	70	-	M	-	-	-	-	-	-	-	-	-	-	M		-
CLO-4 :	Outline the importance of medical device classification based on the application and ISO standards	1	80	70	-	-	H	-	-	-	-	-	-	-	-	M	-	M	-
CLO-5 :	Describe the Indian medical device regulatory system	1	80	70	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	Outline the job opportunities in regulatory affairs in India	1,2	80	70	-	-	-	-	-	-	-	-	-	-	-	L	-	-	-

Duration (hour)		Basic Troubleshooting Techniques& Testing Procedures	Fault Diagnosis in Analog, Digital Integrated Circuits and Home care device	Biomedical Machine Troubleshooting in Hospitals	Medical Device Classification and Standards	Medical Device Regulatory System in India
		9	9	9	9	9
S-1	SLO-1	Equipment failure and its types	Characteristics of ideal op-amps	Troubleshooting- ECG Machine	Global Harmonization Task Force (GHTF) definition for medical device	Importance of regulatory system
	SLO-2	Causes of Equipment failure	Typical op-amp based medical circuits	And its preventive maintenance	Medical Device Life Cycle: Identify, Characterize	Market Overview
S-2	SLO-1	Functional block diagram of a troubleshooting system	Typical op-amp based medical circuits	Troubleshooting- EEG Machine	Medical Device Life Cycle: Optimize, Verify/Validate	Overview of Regulatory Environment
	SLO-2	Functional block diagram of a troubleshooting system	Fault diagnosis in op-amp circuits	And its preventive maintenance	Global Perspective on medical device regulations: USA, European Union	Overview of Regulatory Environment
S-3	SLO-1	Troubleshooting process	Example: Inverting amplifier troubleshooting process	Troubleshooting- defibrillator, suction machine	Global Perspective on medical device regulations: Canada, Australia, Japan	Functions Undertaken by DCGI and Central Government
	SLO-2	Fault finding aids	Typical Faults in digital circuits	And its preventive maintenance	Medical device classification: USA	Functions Undertaken by the FDA and State Governments
S-4	SLO-1	Troubleshooting techniques: Preliminary Observations	Different testing methods in digital circuits: Functional Testing, DC Test	Troubleshooting- electrosurgical unit	Medical device classification: European Union, GHTF	Indian Pharmacopoeia Commission
	SLO-2	Troubleshooting techniques: Functional block diagram approach	AC Test	And its preventive maintenance	Premarket Notification 510(k), Premarket Approval	Details of Key Regulator
S-5	SLO-1	Troubleshooting techniques: Split half method	Digital IC Troubleshooter:, Logic clip, Logic probe	Troubleshooting- anesthesia machine	Standards and its need	Organization Chart — CDSCO

	SLO-2	*Application of Split half method in circuit troubleshooting*	*Digital IC Troubleshooters: Logic pulser, Logic current tracer*	*And its preventive maintenance*	*ISO 9000 core standards: Basic overview*	*Role of Distributors or Local Subsidiaries*
S-6	**SLO-1**	*Troubleshooting techniques: Systematic Troubleshooting*	*Digital IC Troubleshooters: Logic comparator*	*Troubleshooting- autoclaves & sterilizers*	*ISO 13485: Basic overview*	*Product Registration*
	SLO-2	*Correction action*	*Circuit board Troubleshooting*	*And its preventive maintenance*	*ISO 14971: Basic overview*	*Manufacturing site and product registration: process flow chart*
S-7	**SLO-1**	*Testing of passive components: Resistors, Capacitors*	*Troubleshooting- oxygen concentrators*	*Troubleshooting- endoscope*	*ISO 10933: Basic overview*	*Quality System Regulation*
	SLO-2	*Testing of passive components: Inductors, Diodes, LDR*	*And its preventive maintenance*	*And its preventive maintenance*	*ISO 14155: Basic overview*	*Technical Material Requirement & Labelling Requirement of Medical Device*
S-8	**SLO-1**	*Testing of active components: BJT*	*Troubleshooting- sphygmomanometers, Analog Blood pressure apparatus*	*Troubleshooting- incubators*	*ISO 11607: Basic overview*	*Manufacturing-Related Regulation*
	SLO-2	*Testing of active components: JFET*	*And its preventive maintenance*	*And its preventive maintenance*	*ISO 11137: Basic overview*	*Clinical Trial-Related Regulation*
S-9	**SLO-1**	*Testing of active components: MOSFET*	*Troubleshooting- nebulizer*	*Troubleshooting- X-ray Machine*	*IEC 60601: Basic overview*	*Commercial Aspect*
	SLO-2	*Testing of variable resistors and its different types*	*And its preventive maintenance*	*And its preventive maintenance*	*IEC 62353: Basic overview*	*Related Agencies/Departments and Ministries*

Learning Resources

1. *Joseph D Bronzino& Donald R Peterson, "Medical Devices and Human Engineering", CRC Press, 4th Edition, 2015*
2. *Myer Kutz, "Biomedical Engineering and Design Handbook- Volume 2: Applications", McGraw-Hill, 2nd Edition, 2009*
3. *Richard Fries, "Reliable Design of Medical Devices", CRC Press, 2nd Edition, 2006*
4. *Basem S EL-Haik & Khalid S Mekki, "Medical Device Design for Six Sigma: A Road Map for Safety and Effectiveness", John Wiley & Sons, 1st Edition, 2008*
5. *John J Tobin & Gary Walsh, "Medical Product Regulatory Affairs- Pharmaceutical, Diagnostics, Medical Devices", Wiley-Blackwell, 1st Edition, 2008*
6. *Norbert Leitgeb, "Safety of Electromedical Devices Law – Risks – Opportunities", SpringerWienNewYork, 1st Edition, 2010*
7. *"Medical Device Regulations Global overview and guiding principles", World Health Organization Geneva, 2003*
8. *Jack Wong and Raymond K Y Tong, "Handbook of Medical device regulatory affairs in Asia", Pan Stanford Publishing Pte. Ltd., 2ndEdition, 2018*
9. *Khandpur R S, "Troubleshooting Electronic Equipment- Includes Repair & Maintenance", Tata McGraw-Hill, 2nd Edition, 2009*
10. *Nicholas Cram & Selby Holder, "Basic Electronic Troubleshooting for Biomedical Technicians", TSTC Publishing, 2nd edition, 2010*
11. *Dan Tomal& Neal Widmer, "Electronic Troubleshooting", McGraw Hill, 3rd edition, 2004*
12. *Ministry of Health &Family Welfare, "Medical Equipment Maintenance Manual- A first line maintenance guide for end users", New Delhi, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECE368T	Course Name	Biomedical Laser Instruments	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Learn the optical characteristics of tissue			
CLR-2 :	Know the functioning of a laser system			
CLR-3 :	Familiarise the applications of laser in ophthalmology, Dermatology and cardiology			
CLR-4 :	Familiarise the applications of laser in Urology, Gynecology and dentistry			
CLR-5 :	Learn the non- thermal applications of laser in medicine			
CLR-6 :	Acquire knowledge on laser safety and management			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. &	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Describe the optical properties of tissues	3	80	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Have a deep understanding on technical aspects of a LASER system	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Describe the applications of laser in ophthalmology, Dermatology and cardiology	3	75	70	-	M	-	-	-	-	-	-	-	-	-	-		M	
CLO-4 :	Describe the applications of laser in Urology, Gynecology and dentistry	3	80	75	-	M	-	-	-	-	-	-	-	-	-	-	M		
CLO-5 :	Explain the non- thermal applications of laser in medicine	3	80	70	-	-M	-	-	-	-	-	-	-	-	-	-	M		
CLO-6 :	Implement the aspects of laser safety	3	80	70	-	-	-	-	-	-	-	M	-	-	-	-	L		

Duration (hour)		Optical properties of the tissues	LASER System	Laser Applications-I	Laser Applications-II	Non Thermal Applications of LASER and Laser safety management
		9	9	9	9	9
S-1	SLO-1	Fundamental Properties of light - Refraction, Reflection, Laws (Snell's law and Fresnel law)	Characteristics of Laser	Disorders in Eye	Lasers in urology- Lithotripsy	Optical coherence tomography-System description
	SLO-2					
S-2	SLO-1	Scattering, Absorption characteristics	Construction and working principle of laser system	Diagnostic Applications of laser in ophthalmology	Therapeutic applications of Lasers in urology	Applications of Optical coherence tomography
	SLO-2					
S-3	SLO-1	Light transport inside the tissue	Pumping Schemes	Therapeutic Applications of laser in ophthalmology	Laproscopy- System description	Elastography
	SLO-2					
S-4	SLO-1	Tissue properties	Classification of Laser	Dermatological disorders	Applications of laser in Gynecology	Laser Induced Fluorescence (LIF)-Imaging,
	SLO-2					
S-5	SLO-1	Laser Characteristics as applied to medicine and biology,	Solid state Laser - Construction and working principle	Applications of Lasers in dermatology	Applications of laser in Gynecology	FLIM Raman Spectroscopy and Imaging
	SLO-2					
S-6	SLO-1	Laser tissue Interactions – Photo chemical, Photo thermal and Photo mechanical interactions	Atomic laser- Construction and working principle	Diagnostic Applications of Lasers in cardiology	Applications of laser in laryngeal surgery	FLIM – Holographic and speckle application of lasers in biology and medicine
	SLO-2					

Commented [MAVM1]:

Commented [MAVM2]:

Commented [MAVM3R2]:

Commented [MAVM4R2]:

S-7	**SLO-1**	*Fluorescence and Speckles*	*Molecular Laser- Construction and working principle*	*Therapeutic Applications of Lasers in cardiology*	*Applications of laser in Otology*	*Types of laser hazards*
	SLO-2					
S-8	**SLO-1**	*Alterations of bio tissue properties during hyper thermal and ablation reactions*	*Dye Laser - Construction and working principle*	*Lasers in Surgery*	*Applications of laser in neurology*	*laser safety*
	SLO-2					
S-9	**SLO-1**	*Photodynamic therapy - Principle and mechanism*	*Semiconductor Laser- Construction and working principle*	*Tissue welding and Soldering*	*Applications of Lasers in dentistry*	*laser risk management,*
	SLO-2					

Learning Resources	1. *Leon Goldman, M.D., & R.James Rockwell, Jr., Lasers in Medicine, Gordon and Breach Science Publishers Inc., 1975.* 2. *Abraham Katzir, Lasers and Optical Fibers in Medicine, Academic Press Edition,1998.*	3. *Tuan Vo Dirh, Biomedical Photonics – Handbook, CRC Press, Bocaraton, 2003.* 4. *Glasser, O., Medical Physics -- Vol 1, 2, 3 Adam Hilgar Brustol Inc, 1987.* 5. *G.David Baxter, Therapeutic Lasers – Theory and practice, Churchill Livingstone Publications*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	*1. Dr. D. Kathirvelu, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anij@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr. D. Ashok kumar, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE369T	Course Name	HOME MEDICARE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understanding the Home health Nursing practice			
CLR-2 :	Explaining the homecare care working with different clients			
CLR-3 :	Demonstrating the various medical devices used at home			
CLR-4 :	Highlighting the advancement in medical technologies			
CLR-5 :	Visualizing the use of wireless technology in health care			
CLR-6 :	Classifying the various mode of healthcare technology at home			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. &	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Applying Home health Nursing practice	3	80	75	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-2 :	Illustrate the homecare care working with different clients	3	80	70	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-3 :	Analyze the various medical devices used at home	3	75	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-4 :	Identify the advancement in medical health technologies	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-5 :	Analyze the use of wireless technology in health care	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-6 :	Describe the various type of healthcare technology at home	3	80	70	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L

Duration (hour)		Introduction to Home health Nursing	Working With Clients	Medical Devices At Home	Advancement In Medical Technologies	Wireless Technology
		9	9	9	9	9
S-1	SLO-1	Home health care – purpose	Basic human needs	Medical devices at home	Advances and trends in health care technologies	Wireless communication basics
	SLO-2	Historical perspective	Communication and interpersonal skills	Medical devices at home	Advances and trends in health care technologies	Wireless communication basics
S-2	SLO-1	Understanding Home heathcare:Applying Theory to clinical practice	Caregiver observation	User centered design and Implementation	Driver impacting the growth of medical Technologies	Types of wireless network
	SLO-2	**Role preparation and implementation**	Caregiver observation	User centered design and Implementation	Driver impacting the growth of medical Technologies	Types of wireless network
S-3	SLO-1	Developing the plan of care and documentation	Recording and reporting, confidentiality	Co-design with old users	Impact of Moore"s law of medical imaging	Body area network
	SLO-2	**Legal and ethical issues in home care**	Recording and reporting, confidentiality	Co-design with old users	Impact of Moore"s law of medical imaging	Body area network
S-4	SLO-1	Case management and leadership strategies	Working with elderly – aging and body systems.	device types – user issues.	E-health and personal healthcare	Emergency rescue
	SLO-2	Organisation of home care system	Working with elderly – aging and body systems.	device types – user issues.	E-health and personal healthcare	Emergency rescue
S-5	SLO-1	Home care organisation	Working with children	Ethical and legal issues. Infant monitors	Defining the future of health Technology	Remote recovery

	SLO-2	*Home care nursing practice*	*Working with children*	*Ethical and legal issues. Infant monitors*	*Defining the future of health Technology*	*Remote recovery*
S-6	**SLO-1**	*Home care nursing practice*	*Need for home care*	*Medical alert services*	*Inventing the future -tools for self-health*	*General health assessments Technology in medical information processing*
	SLO-2	*Role of home care nurse and orientation strategies*	*Need for home care.*	*Medical alert services*	*Inventing the future -tools for self-health*	*General health assessments Technology in medical information processing*
S-7	**SLO-1**	*Environmental influences on home care*	*Mobility transfers and ambulation*	*Activity monitors*	*Future of Nano fabrication molecular scale devices*	*Future trends in healthcare technology*
	SLO-2	*Environmental influences on home care*	*Mobility transfers and ambulation*	*Activity monitors*	*Future of Nano fabrication molecular scale devices*	*Future trends in healthcare technology*
S-8	**SLO-1**	*Infection control in home*	*Range of motion exercises*	*The ventilator dependent patient*	*Future of telemedicine*	*Paradoxes of progress: Implications for home health care*
	SLO-2	*Infection control in home*	*Range of motion exercises*	*Device for patient with congestive heart failure*	*Future of telemedicine*	*Paradoxes of progress: Implications for home health care*
S-9	**SLO-1**	*Patient education in home*	*Skin care and comfort measures*	*Device for Patient with chronic Obstructive pulmonary disease*	*Future of medical computing*	*Cost of home healthcare*
	SLO-2	*Patient education in home*	*Skin care and comfort measures*	*Device for patient with Diabetic*	*Future of medical computing*	*Direction for emerging technology*

Learning Resources	*1. Robyn Rice, "Home care nursing practice: Concepts and Application", 4th edition, Elsevier, 2006.* *2. LodewijkBos, "Handbook of Digital Homecare: Successes and Failures", Springer, 2011.*	*3.* Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph. D,Bronzino,"Clinical Engineering", CRC Press, 2010. *4.* Kenneth J. Turner, "Advances in Home Care Technologies: Results of the match Project", Springer, 2011.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	*1.Dr. D. Ashok Kumar, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Mrs. Lakshmi Prabha.P, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE460T	Course Name	ACOUSTICS AND OPTICAL IMAGING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	To study in-depth the various optical properties of tissues and light interactions with tissues			
CLR-2 :	To study about various optical sources and instrumentation for various measurements			
CLR-3 :	To study about photonic detection and imaging techniques			
CLR-4 :	To understand the special techniques like optical holography			
CLR-5 :	To make them understand the working principles of optical imaging systems			
CLR-6 :	To Utilize the imaging techniques for various applications			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. &	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Analyze in-depth about the various optical properties of tissues and light interactions with tissues	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-2 :	Illustrate the hardware and techniques involved in acoustic imaging	3	80	70	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-3 :	Describe the optical properties of tissues	3	75	70	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-4 :	Analyze the physics behind optical holography	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-5 :	Identify the principle behind modern imaging techniques	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-6 :	Apply the imaging modality for interpretation	3	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L

Duration (hour)		PHYSICS OF ACOUSTICS	ACOUSTIC IMAGING	OPTICAL PROPERTIES OF TISSUES	OPTICAL HOLOGRAPHY	PHOTONIC DETECTION AND IMAGING TECHNIQUES
		9	9	9	9	9
S-1	SLO-1	***The sine wave , sound in media-particle motion***	*Fundamentals of photo acoustic tomography*	*Fundamental Optical Properties*	*Fundamentals – Object wave*	*Life time based imaging*
	SLO-2	***propagation of sound***	*Photo acoustic effect*	*Refraction, scattering, absorption*	*photography*	*Techniques for Lifetime-Based Imaging*
S-2	SLO-1	***Speed of sound - wavelength and frequency***	*Image reconstruction methods*	*Light Transport in Tissue*	*holography*	*Specifics of FLIM Data Analysis*
	SLO-2	***complex waves- harmonics***	*Instrumentation*	*Numerical Approach: Monte Carlo Simulations*	***interference during recording***	***Selected FLIM Applications***
S-3	SLO-1	***Phase, partials ,octaves, spectrum***	*Transducer array*	*Kubelka–Munk Model*	*diffraction during reconstruction*	*confocal microscopy*
	SLO-2	***electrical, mechanical and acoustic analogs***	*Transducer array-based photoacoustic tomography*	*Tissue Properties*	*Imaging techniques –In line hologram*	*Image Formation in Scanning Microscopes*
S-4	SLO-1	***Wave phenomenon***	*Array-based PAT System*	*Refractive Indices*	*off axis hologram, fourier hologram*	*Applications of Depth Discrimination*
	SLO-2	***wavefronts, Interference,***	*2-D Imaging*	*Scattering Properties*	*fraunhofer hologram, reflection hologram*	*Fluorescence Microscopy*
S-5	SLO-1	***reflection, scattering***	*3-D Imaging*	*Absorption Properties*	*Optical properties of holographic imaging*	*Optical Architectures*
	SLO-2	***diffraction, refraction***	*4-D Imaging*	*Light Interactions with a Strongly Scattering Tissue*	*hologram of an object*	*Abberation Correction*

S-6	**SLO-1**	***doppler effect , convection***	*Photoacoustic microscopy*	*Continuous Wave Light , Polarized Light,• Short Light Pulses, Diffuse Photon-Density Waves*	*Image equation, angular magnification*	*Near-Field Optical Microscopy*
	SLO-2	***Sound levels and decibel: ratios versus differences***	*computed microscopy*	*Optothermal Interactions*	*longitudinal magnification, image aberrations*	*Biological Applications of Near-Field Optical Microscopy*
S-7	**SLO-1**	***logarithms , decibels, reference levels***	*Optical-resolution*	*Temperature Rise and Tissue Damage ,*	*Properties of light source -spectral bandwidth*	*Special Near-Field Techniques for Biological Applications*
	SLO-2	***Logarithmic and exponential forms compared***	*Acoustic-resolution*	*Optothermal and Optoacoustic Effects*	*image plane holograms*	*Principles of Operation of Optical Coherence Tomography*
S-8	**SLO-1**	***acoustic power***	*C-scan photoacoustic Microscopy*	*Fluorescence*	*Image luminance- without pupil*	*Applications of Optical Coherence Tomography*
	SLO-2	***Measuring sound pressure level***	*Photoacoustic computed microscopy*	*Formation of Speckles*	*with pupil, image plane holograms*	*Thermal imaging for biological and medical diagnosis*
S-9	**SLO-1**	***sine wave measurement***	*Photoacoustic microscopy based on acoustic lens with variable focal length*	*Detectors: solid state detectors*	*speckles- diffuser*	*Infrared Radiation and Thermal Imaging*
	SLO-2	*Examples*	*Confocal photoacoustic microscopy using a single multifunctional Lens*	*time resolved and phase resolved detectors*	*resolution, incoherent illumination*	*Applications of Infrared Thermal Imaging*

Learning Resources	1. *F. Alton Everest, Ken Pohlmann , "Master Handbook of Acoustics" McGraw-Hill, sixth edition, 2014* 2. *Huabei Jiang, " PhotoacousticTomography" CRC press, Taylor & Francis Group,first edition, 2015.* 3. *Jose Luis del Cura, Pedro Segui, Carlos Nicolau, "Learning Ultrasound Imaging"springer,first edition 2012.*	4. *Peter R. Hoskins, Kevin Martin, Abigail Thrush, "Diagnostic Ultrasound: Physics and Equipment", Cambridge university press,second edition, 2010* 5. *Gerhard K. Ackermann, Jürgen Eichler, "Holography: A Practical Approach", WILEY-VCH Verlag GmbH & Co, first edition, 2008.* 6. *Tuan Vo Dirh, "Biomedical photonics – Handbook", CRC Press, second edition, 2003*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr.D.Kathirvelu, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE461T	Course Name	MACHINE VISION IN MEDICAL TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Utilize the types and concepts of machine vision			
CLR-2 :	Utilize the techniques involved in motion analysis			
CLR-3 :	Utilize the properties and techniques in 3D reconstruction			
CLR-4 :	Utilize the algorithm behind different methods of photogrammetry			
CLR-5 :	Applying the machine vision techniques to medical applications			
CLR-6 :	Utilize the numerical techniques for various medical applications			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. &	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Familiarize with the machine vision and its problems	3	80	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-2 :	Explain the applications of differential vision and motion analysis	3	80	70	L	M	L	-	-	-	-	-	-	-	-	-	L	-	L
CLO-3 :	Describe and understand the concept of three dimensional reconstruction	3	75	70	L	M	L	L	-	-	-	-	-	-	-	M	L	-	L
CLO-4 :	Use stereo vision techniques and optical flow methods to study imaging techniques	3	80	75	M	-	-	L	-	-	-	-	-	-	-	M	L	-	L
CLO-5 :	Use contemporary numerical and simulation tools to implement methods and algorithms	3	80	70	M	-	M	L	M	-	-	-	-	-	-	-	L	-	L
CLO-6 :	Apply the machine vision in medical technology	3	80	70	M	-	-	-	M	-	-	-	-	-	-	-	L	-	L

Duration (hour)		Machine Learning For Machine Vision	Visualizing Of Objects In Motion	3D Reconstruction –Basics And Methods	Photogrammetry And Stereo Methods	Applying Computational Vision
		9	9	9	9	9
S-1	SLO-1	Learning and inference in vision	Two-frame structure	2D and 3D feature-based alignment	Photometric calibration	Automated Visual Inspection
	SLO-2	Human Vision	Two-frame structure from motion	Correlating 2D and 3D	Noise level estimation	Automated Visual Inspection with CT image
S-2	SLO-1	Geometric primitives	Perspective and projective factorization	Shape from texture	High dynamic range imaging	Computer Vision in Interventional Cardiology
	SLO-2	2D and 3D transformations	Constrained structure and motion	Shape from shading and photometric stereo	Optical blur (spatial response) estimation	Computer Vision using CT image
S-3	SLO-1	Photometric image formation	Dense motion estimation- Definition	Shape from focus	Super-resolution	Fusion of three dimensional quantitative coronary angiography and intracoronary imaging for coronary interventions
	SLO-2	Global optimization	Dense motion estimation	Active range finding	blur removal	Merging Two image
S-4	SLO-1	Low level vision : Definition , example	Parametric motion	Surface representations	Image matting and compositing	Feature centric lesion detection and retrieval in thoracic images
	SLO-2	classical filtering operations	Parametric motion- application in analysis	Interpolation, simplification	Optimization-based matting	Algorithm for retrieval
S-5	SLO-1	Edge detection: sobel	Motion models-Definitions	Point-based representation-Definition	Texture analysis and synthesis	Colorization of image after retrieval

	SLO-2	*Geometric intrinsic calibration*	*Motion models-application*	*Point-based representations -Examples*	*Hole filling and inpainting*	*False coloring*
S-6	**SLO-1**	*Middle level: Definition , example*	*The Geometry of multiple views*	*Volumetric representations*	*Epipolar geometry*	*Medical image registration*
	SLO-2	*Segmentation by clustering*	*Affine structure from motion*	*Implicit surfaces and level sets*	*Rectification*	*For thermal image & digital image*
S-7	**SLO-1**	*Hough Transform*	*Elements of Affine Geometry*	*Model-based reconstruction*	*Sparse correspondence*	*Z-keying and background replacement*
	SLO-2	*Case study: Human Iris location*	*Affine structure and motion from two images*	*Heads and faces*	*3D curves and profiles*	*In registered image*
S-8	**SLO-1**	*High level: Definition , example*	*Affine structure and motion from multiple images*	*Application: Facial animation*	*Dense correspondence*	*Volumetric and 3D surface reconstruction*
	SLO-2	*Model based vision*	*Application to Gait analysis*	*Whole body modeling and tracking*	*Sub-pixel estimation and uncertainty*	*Shape from silhouettes*
S-9	**SLO-1**	*Regression model- definition*	*Image Stitching - Concept*	*Rendering- Layered depth images*	*Multi-view stereo*	*Video denoising*
	SLO-2	*graphical model*	*Image Stitching – Application*	*Light fields and Lumigraphs – 3D*	*Shape from silhouettes*	*Video denoising for live endoscopic images*

Learning Resources	1. *Richard Szeliski ,"Computer Vision: Algorithms and Applications", Springer, 2010* 2. *E R Davies , "Computer & Machine Vision : Theory , Algorithms, Practicalities" 4th Edition , Elsevier, 2012* 3. *Computer vision – A modern Approach, David A Forsyth & Jean ponce, Prentice Hall, 2002.* 4. *Milan Sonka ,Vaclav Hlavac, Roger Boyle, "Image processing, analysis and and machine vision" (3. ed.)., 2008* 5. *Chi Hau Chen , "Computer Vision in Medical Imaging"- Series in Computer Vision – Vol 2, World Scientific Publishing Co Ltd, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	*1. Mrs. A Bhargavi Haripriya, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr. U. Snekhalatha, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

B. Tech in Electronics and Communication Engineering
(with Specialization in BioMedical Engineering)

2018 Regulations

Open Elective Courses (O)

Department of Electronics and Communication Engineering
SRM Institute of Science and Technology
SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECO101T	Course Name	Short Range Wireless Communication	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards	Nil		

Course Learning Rationale (CLR):	Understand the concept of Short range Wireless Communication
CLR-1 :	*Overview of different modulation scheme and wireless system*
CLR-2 :	*To understand the various components used to implement a short-range radio system.*
CLR-3 :	*Analysis of the various kinds of transmitters and receivers used for Short range Wireless Communication.*
CLR-4 :	*To know about regulations and standards of ISM band communications*
CLR-5 :	*Design and analysis of short-range radio like UWB and Visible light.*

Course Learning Outcomes (CLO):	The purpose of this course is to introduce practically all aspects of radio communication including wave propagation, antennas, transmitters, receivers, design principles, telecommunication regulations	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	To cover the various forms of signals used for information transmission and modulation, and overall wireless system properties.	2	*80*	*70*
CLO-2 :	To present various component types that can be used to implement a short-range radio system.	2	*85*	*75*
CLO-3 :	To describe the various kinds of transmitters and receivers.	2	*75*	*70*
CLO-4 :	To covers regulations and standards of ISM band communications	2	*85*	*80*
CLO-5 :	To covers some of the most important new developments in short-range radio like UWB and Visible light.	2	*85*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
L	-	-	-	-	-	-	-	-	-	-	-	-	H	-
-	-	M	L	-	-	-	-	-	-	-	-	H	-	-
-	-	H	M	-	-	-	-	-	-	-	-	-	H	-
M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
-	-	L	M	-	-	-	-	-	-	-	-	-	-	H

Duration (hour)		Wireless Systems	Baseband Coding basics	RF transceivers	Wireless standards	Optical wireless Technologies
		9	9	9	9	9
S-1	SLO-1	*Introduction to wireless systems*	*Types of Antennas-Dipole, groundplane, loop*	*RF Receivers- Introduction*	*Technical Background to the WPAN Concept - Regulation and Standardization Issues*	*Fundamentals of UROOF Technologies*
	SLO-2	*Reasons for the Spread of Wireless Applications*	*Helical, Patch antennas*	*RF Source-Frequency control*	*European Consortium: Overview*	*Conversion from RF to Optical Domain*
S-2	SLO-1	*Characteristics of Short-range Radio*	*Antenna Characteristics-Impedence, directivity and gain, Effective area*	*Modulation types*	*Millimeter-Wave Applications and Services - PAN scenarios in the IST Magnet project*	*Conversion from Optical to RF Domain*
	SLO-2	*Wireless Applications*	*Polarization, Bandwidth, Antenna factor*	*Amplifiers*	*Typical LDR services connected to the IST-FP6 MAGNET project*	*Optical Microwave Mixing Used for UWB Over Systems*
S-3	SLO-1	*Elements of Wireless Communication Systems-Transmitter*	*Baseband Data Format and Protocol - Radio Communication Link Diagram*	*Impedance matching in transmitter and receivers*	*Frequency Regulation and Standardization Issues - Optional UM4 usage models issued from the IEEE802.15.3c TG*	*Integrated UROOF Transceiver (IUT)*
	SLO-2	*Elements of Wireless Communication Systems-Receiver*	*Code Hopping*	*Filtering*	*Flexible antenna gain, 60 GHz regulation status for wireless transmissions.*	*Mixed Wireless-wired UROOF Channel, Carrier-to-noise Ratio*
S-4	SLO-1	*Wireless Local Area Networks (WLAN)-WIFI*	*Baseband Coding-Digital systems*	*SAW band pass filter matching*	*Channel Propagation Characterization and Modeling- 60 GHz Propagation Measurements*	*Laser and Photodetector Noise Baseline,*
	SLO-2	*Network Architecture*	*Wireless Microphone System*	*Tuned Radio Frequency (TRF)*	*Propagation Channel Characterization*	*Clipping Distortion Implication , Latency*
S-5	SLO-1	*Bluetooth Transceiver*	*RF Frequency and Bandwidth-factors*	*ASH Receiver*	*Multipath Propagation Modeling*	*Modelling the Propagation through the Fibre*

	SLO-2	*Bluetooth Modes*	*Propagation characteristics*	*Super regenerative Receiver –Block diagram*	*France Telecom Propagation Channel Models*	*Analysis of UWB Technologies for UROOF- Comparing UWB Technologies for Radio-over- fibre*
S-6	**SLO-1**	*Zigbee Architecture, Frame Structure*	*Modulation types*	*Super regenerative Receiver – Operation*	*MSK-Based System for LOS Gb/s Communications*	*MB-OFDM Over Multimode Fibre*
	SLO-2	*Applications and conflicts*	*Modulation for digital event communication*	*Super heterodyne Receiver-Block diagram*	*System architecture for an MSK-based system to operate in a LOS channel.*	*All-optical Generation of Ultra-wideband Impulse Radio*
S-7	**SLO-1**	*Ultra-wideband Technology-Bit Sequence detection*	*Continuous Digital Communication*	*Super heterodyne Receiver- Operation*	*OFDM-Based System for NLOS Gb/s Communications*	*Operation Principles and Theoretical Approach*
	SLO-2	*UWB Block Diagram*	*Advanced Digital Modulation*	*Direct Conversion Receiver- Block diagram*	*System architecture for an OFDM-based system to operate in a NLOS channel.*	*VLC Link –Transmitter*
S-8	**SLO-1**	*Wireless Modules-Japan,UK,USA*	*Spread Spectrum-DHSS*	*Direct Conversion Receiver- Operation*	*System Design Aspects-Channel Plan*	*The VLC Channel*
	SLO-2	*Wireless Modules-Austria, Honeywell, Norway*	*Spread Spectrum-FHSS*	*Digital Receivers-Software radio*	*60 GHz Channel Characteristics, Baseband Modulation: OFDM versus Single Carrier*	*Receiver, Modulation*
S-9	**SLO-1**	*FCC Regulations-Terms and definitions*	*RFID-transceiver*	*Software radio operation*	*60 GHz Analog Front-End Architectures*	*Potential Applications*
	SLO-2	*Nomenclature for defining Emission, modulation and transmission*	*Design issues for RFID*	*Repeaters*	*Multiple Antenna Technologies*	*Challenges*

Learning Resources

1. Alan Bensky, "Short range Wireless Communications-Fundamentals of RF system design and Applications", Elsevier Inc, 2004
2. Antti V. Raisanen, Arto Lehto, "Radio engineering for wireless communication and sensor applications", Artech House, 2003
3. Rolf Kraemer and Marcos Katz, "Short-range wireless communications emerging technologies and applications", Wiley WWRF series, March 2009
4. Shlomi Arnon, John Barry, George Karagiannidis, Robert Schober, Murat Uysal, "Advanced Optical Wireless Communication Systems" , Cambridge University Press, 2012

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Anuj Kumar, Bombardier* Transportation, Ahmedabad, *kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor* of ECE, CEG, Anna University, *meena68@annauniv.edu*	*1. Dr. J. Subhashini, SRM IST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18EC0102J	Course Name	Electronic Circuits and Systems	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards			

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLR-1 :	Provide a basis for understanding semiconductor material, how a pn junction is formed and its principle of operation																		
CLR-2 :	Describe the basic structure, operation and characteristics of transistors BJTs and FETs, and discuss their use as a switch and an amplifier																		
CLR-3 :	Learn the basics of op-amp: the principle, operation, characteristics and fundamentally important circuits																		
CLR-4 :	Describe and analyze the basic operation of sinusoidal oscillators and use a 555 Timer in an oscillator application.																		
CLR-5 :	Learn the fundamentals of analog and digital communication, networking, radio transmission and mobile telephones																		
CLR-6 :	Encourage the learner to assemble and test real circuits in the laboratory																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	Understand the operation, characteristics, parameters and specifications of semiconductor diodes and demonstrate its important applications	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Review the transistor (BJT & FET) construction, operation, characteristics and parameters, as well as its application in amplification and switching.	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Identify different configurations of op-amp analyze the parameters of op-amp and observe the frequency response of operational-amplifier.	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Understand & demonstrate different applications based on operational-amplifier and special linear ICs	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Understand the basic concepts and techniques of telecommunication systems and networks	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Understand how circuit behavior can be studied with a computer, using a circuit simulation software	2	90	80	-	-	H	-	H	-	-	-	-	L	-	M	L	-	-

		Learning Unit / Module 1 (12)	Learning Unit / Module 2 (12)	Learning Unit / Module 3 (12)	Learning Unit / Module 4 (12)	Learning Unit / Module 5 (12)
Duration (hour)		Active Discrete Components & Circuits – I	Active Discrete Components & Circuits – II	Linear Integrated Circuits	Oscillators and Timers	Telecommunications
S-1	SLO-1	Conduction in semiconductors	JFETs: Structure & Operation	Introduction to Op-amp	RC Phase-Shift oscillator Operation	Analog & Digital Communication: Stages in telecommunication systems
	SLO-2	Conduction in diodes	Characteristics & Parameters	Basic op-amp and its characteristics	& Design	Carriers and Modulation
S-2	SLO-1	Basic operation of PN junction diode	JFET Biasing (Voltage-Divider Biasing)	op-amp modes	Wein bridge Oscillator operation	Carriers and Modulation
	SLO-2	VI Characteristics of diode	CS-JFET Amplifier operation	parameters	& Design	Pulse Modulation
S-3	SLO-1	***Lab-1: VI Characteristics of PN Junction Diode***	***Lab-4: Design & Analysis of CE BJT Amplifier***	***Lab-7: Negative Feedback op-amp circuits***	***Lab-10: Analysis & Design of RC Oscillators***	***Lab-13: Demonstration of AM & FM***
	SLO-2					
S-4	SLO-1					
	SLO-2					
S-5	SLO-1	Applications of diode: HWR & FWR	MOSFETs: Structure	Op-amp circuits: Scale changer, adder, subtractor	LC oscillators operation: Hartley Oscillator	Pulse Modulation
	SLO-2	Clippers & Clampers	Operation	HWR & FWR	Colpitts Oscillator	Digital Transmission, Frequency Division MultiplexingTime Division Multiplexing
S-6	SLO-1	Basic operation of Zener diode and its VI characteristics	Characteristics	Clipper &Clamper	555 Timer IC: Basic Operation	Networks: RS-232, circuit switching

	SLO-2	*Zener diode as a voltage regulator*	*Parameters*	*Log & Antilog amplifiers*	*Astable Operation*	*Message switching, TCP/IP*
S-7	**SLO-1**	***Lab-2: VI Characteristics of Zener Diode***	***Lab-5: Design & Analysis of CS-JFET Amplifier***	***Lab-8: Op-amp Circuits-I***	***Lab-11: 555 Timer Operation & Applications***	***Lab-14: Demonstration of Pulse Modulation***
	SLO-2					
S-8	**SLO-1**					
	SLO-2					
S-9	**SLO-1**	*BJTs: Structure & Operation*	*MOSFET as an amplifier*	*Instrumentation amplifier*	*Monostable Operation*	*Radio Transmission: Electromagnetic Spectrum, ground waves, sky waves*
	SLO-2	*Characteristics & Parameters*	*MOSFET as a switch*	*Comparator*	*Applications of 555 Timer*	*antennas, directional transmissions,*
S-10	**SLO-1**	*CE BJT amplifier operation*	*MOSFET Biasing (Voltage-Divider Biasing)*	*Comparator applications*	*Applications of 555 Timer*	*Transmitters, Receivers*
	SLO-2	*Differential amplifier operation*	*CS-MOSFET amplifier operation*	*Schmitt trigger*	*Voltage-Controlled Oscillators*	*Mobile telephones*
S-11	**SLO-1**					
	SLO-2	***Lab-3: Applications of PN Junction diode and Zener diode***	***Lab-6: Design & Analysis of CS-MOSFET Amplifier***	***Lab-9: Op-amp Circuits-II***	***Lab-12: VCO Operation***	***Mini Project / Model Practical Examination***
S-12	**SLO-1**					
	SLO-2					

Learning Resources	**1.** *Owen Bishop, "Electronic Circuits and Systems", 4th edition, Elsevier, 2011.* 2. *Harry Kybett, Earl Boysen, "All New Electronics", 3rd edition, Wiley, 2008.*	3. *Paul Scherz, "Practical Electronics for Inventors", McGraw-Hill, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. Rajesh Agarwal, SRM IST*

Course Code	18ECO103T	Course Name	Modern Wireless Communication System	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Learn to analyze the transmission of various wireless communication systems
CLR-2 :	Understand the fundamentals of various networks in wireless communication
CLR-3 :	Understand the techniques involved in personal communication services.
CLR-4 :	Introduce various wireless systems for 3G and future communication
CLR-5 :	Learn to analyze wireless networks for short range communication
CLR-6 :	Understand the Fundamentals, Techniques and Networks of Wireless Communication Systems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Discuss the fundamentals of transmission in wireless systems	2,3	80	75
CLO-2 :	Provide an overview of various approaches to communication networks	2,3	80	85
CLO-3 :	Study the numerous different-generation technologies with their individual pros and cons	2,3	85	85
CLO-4 :	Discuss about the principles of operation of the different access technologies like FDMA, TDMA, SDMA and CDMA and their pros and cons.	2,3	85	80
CLO-5 :	Learn about the various mobile data services and short range networks.	2,3	85	80
CLO-6 :	Gain knowledge on *Fundamentals, Techniques and Networks of Wireless Communication Systems*	2,3	85	80

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO–1: Professional Achievement	14 PSO – 2: Project Management Techniques	15 PSO – 3: Analyze & Research
CLO-1 :	-	-	-	H	-	-	-	-	-	-	-	-	H		
CLO-2 :	-	-	-	H	-	-	-	-	-	-	-	-	-	-	H
CLO-3 :	-	-	-	H	-	-	-	-	-	-	-	-	M	-	H
CLO-4 :	-	-	-	H	-	-	-	-	-	-	-	-	M	-	H
CLO-5 :	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-6 :	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-

Duration (hour)		Transmission Fundamentals	Network Concepts	Personal Communication Services	3G and Beyond	Mobile Data Services and Short- Range Network
		9	9	9	9	9
S-1	SLO-1	*Cellphone Generations*	*Communication Networks*	*Personal communication Introduction, HSCSD, GPRS, D-AMPS, CDMA One, CDMA Two, Packet Data Systems*	*3G Introduction*	*Mobile Data Services Introduction Messaging, wireless web, WAP, site design Short-Range Wireless Networks: Unlicensed spectrum, WLANs, cordless telephony, IrDA, Bluetooth Smart Phones: Future phones, mobile OSs, smart phone applications.*
	SLO-2	*1G and 2G*	*LANs*	*GSM*	*IMT-2000 Introduction*	*Data Services*
S-2	SLO-1	*2.5G*	*MANs*	*GSM*	*IMT-2000*	*Messaging*
	SLO-2	*3G*	*WANs*	*HSCSD*	*IMT-2000*	*Wireless web*
S-3	SLO-1	*4G Transmission Introduction*	*Circuit switching*	*HSCSD*	*W-CDMA Introduction*	*WAP*
	SLO-2	*4G Transmission Fundamentals*	*Packet switching*	*GPRS*	*W-CDMA*	*Site design*
S-4	SLO-1	*Time domain concepts*	*ATM Cellular Networks Introduction*	*GPRS*	*CDMA 2000 Introduction*	*Short-Range Wireless Networks*

	SLO-2	*Frequency domain concepts*	*Cells*	*D-AMPS*	*EDGE*	*Unlicensed spectrum*
S 5-6	**SLO-1**	*Radio Media*	*Duplexing*	*D-AMPS*	*EDGE*	*WLANs*
	SLO-2					
S-7	**SLO-1**	*Analog Vs Digital*	*Multiplexing*	*CDMA Introduction*	*Wi-Fi Introduction*	*Cordless telephony*
	SLO-2	*Channel capacity*	*Voice coding*	*CDMA One*	*Wi-Fi*	*IrDA*
S-8	**SLO-1**	*Transmission media*	*Multiple Access Techniques: FDMA*	*CDMA One*	*WiMAX Introduction*	*Bluetooth Smart Phones*
	SLO-2	*Signaling Schemes*	*TDMA, SDMA*	*CDMA Two*	*WiMAX*	*Future phones*
S-9	**SLO-1**	*Carrier-based signaling,*	*CDMA*	*CDMA Two*	*OFDM*	*Mobile OSs*
	SLO-2	*Spread-spectrum signaling*	*Spectral efficiency*	*Packet Data Systems*	*MIMO*	*Smart phone applications*

Learning Resources	1. Simon Haykin, David Koilpillai, Michael Moher," Modern Wireless Communication", 1/e, Pearson Education, 2011 2. Rappaport T.S, "Wireless Communications: Principles and Practice", 2nd edition, Pearson education. 3. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, Aug. 2005. 4. Andy Dornan, "The essential guide to wireless communications applications: from cellular systems to Wi-Fi", 2nd Edition, Prentice Hall, 2002	5. Ian F.Akyildiz, David M. Gutierrez Estevez, and Elias Chavarria Reyes, " The evolution of 4G cellular systems: LTE advanced", Physical communication, Volume 3, No. 4, pp. 217-298, Dec. 2010 6. William Stallings, " Wireless Communication & Networking", Pearson Education Asia, 2004 7. Andrea .F.Molisch, "Wireless communications", 2nd edition, Wiley Publications.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECO104J	Course Name	Audio and Speech Signal Processing	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	To explore about Speech signal processing
CLR-2 :	To explore about the human auditory system
CLR-3 :	Feature Extraction of Speech signal using Time characteristics
CLR-4 :	Frequency characteristics of Speech signal
CLR-5 :	Provide a foundation for developing applications in this field.
CLR-6 :	Understand the concept of speech processing both in time and frequency domain

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning: Level of Thinking (Bloom)	Learning: Expected Proficiency (%)	Learning: Expected Attainment (%)
CLO-1 :	Understand the functioning of the human vocal and auditory systems in terms of signal processing	1	90	68
CLO-2 :	Analyze the function of feature extraction in speech and audio signal processing using Time Domain Characteristics	2	85	67
CLO-3 :	Understand the frequency characteristics of speech signal	2	85	68
CLO-4 :	Understand the Digital models for speech signal	1&2	85	65
CLO-5 :	Understand the elements of music	2&3	85	66
CLO-6:	Understand Speech signal processing in time and frequency domain and their models.	1,2,3	85	68

CLO	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO – 1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze &Research
CLO-1	H		H		H				-	-	-	-	M	H	
CLO-2	H			H				M	-	-	-	-	M		H
CLO-3	H		H			M		M	-	-	-	-		H	H
CLO-4	H		H	H					-	-	-	-	H	M	
CLO-5			H		H			H	-	-	-	-	H		H
CLO-6	H		H			M		H	-	-	-	-		M	M

Duration (hour)		Learning Unit / Module 1 Basic Audio Processing	Learning Unit / Module 2 Human auditory system	Learning Unit / Module 3 Speech Signal Analysis in Time Domain	Learning Unit / Module 4 Speech Signal Analysis in Frequency Domain	Learning Unit / Module 5 Speech and Audio processing applications
		12	12	12	12	12
S-1	SLO-1	Introduction to Digital audio	Human auditory system	Speech signal analysis	Short Time Fourier analysis	Introduction to Speech recognition
	SLO-2	Capturing and converting sound	Human auditory system	Speech signal analysis	Short Time Fourier analysis	Introduction to Speech recognition
S-2	SLO-1	Sampling of sound wave	simplified model of cochlea	Segmental, sub-segmental levels	Filter bank analysis	Complete system for an isolated word recognition with vector quantization /DTW
	SLO-2	Handling audio in MATLAB	simplified model of cochlea	Suprasegmental levels	Formant extraction and Pitch extraction	Complete system for an isolated word recognition with vector quantization /DTW
S-3	SLO-1	**Lab 1: Read & write a speech signal, Record a speech signal, playback, convert into a wave file, plot the speech signal, and spectrogram plot.**	**Lab 4: Short-term energy of a speech signal**	**Lab 7: Estimation of pitch period using simplified inverse filter tracking (SIFT) algorithm**	**Lab 10: Phoneme-level segmentation of speech**	**Lab 13: Compute pitch period and fundamental frequency for speech signal**
	SLO-2					
S-4	SLO-1					
	SLO-2					
S-5	SLO-1	Normalization	Sound pressure level and loudness	Time domain parameters of speech signal	Homomorphic speech analysis	Complete system for speaker identification, verification
	SLO-2	Audio processing	Sound pressure level and loudness	Time domain parameters of speech signal	Cepstral analysis of Speech	Introduction to speech enhancement
S-6	SLO-1	Segmentation	Sound intensity and Decibel sound levels	Methods for extracting the parameters Energy	Formant and Pitch Estimation	Introduction to speech enhancement
	SLO-2	Analysis of window sizing	Sound intensity and Decibel sound levels	Average ,Magnitude	Linear Predictive analysis of speech	Speech enhancement using spectral subtraction method

S-7	SLO-1					
	SLO-2	***Lab 2: Convert into a wave file, plot the speech signal, and spectrogram plot***	*Lab 5:* ***Short-time Fourier transform magnitude spectrum***	***Lab 8: Estimation of pitch period using harmonic product spectrum***	***Lab 11:To study the quantization and aliasing effect of speech signal***	***Lab 14: Short term speech analysis***
S-8	SLO-1					
	SLO-2					
S-9	SLO-1	*Visualization*	*Concept of critical band*	*Zero crossing Rate*	*Autocorrelation method, Covariance method*	*Introduction to Text to speech conversion*
	SLO-2	*Sound generation*	*Uniform filter bank , Non- uniform filter bank*	*Silence Discrimination using ZCR and energy*	*Solution of LPC equations*	*Introduction to Musical instrument classification*
S-10	SLO-1	*Speech production mechanism, Charistics of speech*	*Mel scale and bark scale,*	*Short Time Auto Correlation Function*	*Durbin's Recursive algorithm, Application of LPC parameters*	*Musical Information retrieval.*
	SLO-2	*Understanding of speech*	*Speech perception: vowel perception*	*Pitch period estimation using Auto Correlation Function*	*Pitch detection using LPC parameters, Formant analysis*	*Sample Programs*
S-11	SLO-1					
	SLO-2	***Lab 3:Cepstrum smoothed magnitude spectrum***	***Lab 6: (i)Linear prediction magnitude spectrum, (ii) (ii) Estimation of formant frequencies using linear prediction***	***Lab 9: Pitch and duration modification using time-domain pitch synchronous overlap and add (TD-PSOLA) method***	***Lab 12:*: Speech signal to symbol transformation using wavesurfer**	***Lab 15: Study of Praat***
S-12	SLO-1					
	SLO-2					

Learning Resources	1. *Ian McLaughlin, "Applied Speech and Audio processing, with MATLAB examples", 1st Edition, Cambridge University Press, 2009* 2. *Ben Gold, Nelson Morgan, Dan Ellis, Wiley, "Speech and Audio Signal Processing: Processing and Perception of Speech and Music", 2nd Edition, John Wiley & Sons, 01-Nov-2011.*	3. *Rabiner,B.H.Juang, "Fundamentals of Speech Recognition", 2 nd Edition, Prentice-hall Signal Processing Series, April 1993* 4. *Ken Pohlmann, "Principles of Digital Audio", 6th Edition, McGraw-Hill, 2007* 5. *A.R.Jayan, "Speech and Audio Signal Processing", ISBN : 978-81-203-5256-8,* ***PHI Learning Pvt. Ltd, 2016.***

Learning Assessment

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

 # CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. S. Dhanalakshmi, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Mrs. K. Harisudha, SRMIST*

Course Code	18ECO105T	Course Name	Underwater Acoustics	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Communication Engineering*	**Data Book / Codes/Standards**		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	**Learning**		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand what is Sound Navigation and Ranging (SONAR) and how it can be used in underwater applications.*			
CLR-2 :	*Study about Ocean Acoustic Processing and sound wave propagation and analyze sea floor characteristics and ocean sounds.*			
CLR-3 :	*Understand about Underwater reverberation and how types of noises affects the underwater acoustics signal data analysis.*			
CLR-4 :	*Study about Acoustic transducers.*			
CLR-5 :	*Know which transducers can be used for underwater applications.*			
***CLR*-6 :**	*Understand the basic theory and signal processing application for underwater communication and navigation.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLO-1 :	*Acquire in-depth knowledge and analyze on Sound Navigation and Ranging (SONAR) equations and it characteristics.*	*L1*	*85*	*65*	M	-	-	-	-	-	-	-	-	-	-	M	L		
CLO-2 :	*Analyze Ocean Acoustic Processing and sound wave propagation.*	*L2*	*85*	*65*	M	H	H	H	H	-	-	-	-	-	-	L	H	H	H
CLO-3 :	*Acquire knowledge and analyze Underwater reverberation and various types of noises.*	*L1&L2*	*85*	*65*	M		H	H	H	-	-	-	-	-	-	L	H	M	H
CLO-4 :	*Acquire knowledge on working of underwater Acoustic transducers.*	*L1*	*85*	*65*	H	H	H	H	H	-	-	-	-	-	-	L	H	H	H
CLO-5 :	*Gain knowledge and apply SONAR concepts for underwater applications.*	*L1& L3*	*85*	*65*	L		H	H	-	-	-	-	-	-	-	L	H	M	H
CLO-6 :	*Understand the development and dynamics of underwater acoustic engineering*	*L2 &L3*	*85*	*65*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		**Learning Unit / Module 1 Sound Navigation and Ranging (SONAR)**	**Learning Unit / Module 2 Ocean Acoustic Processing and sound wave propagation**	**Learning Unit / Module 3 Reverberation and Noises**	**Learning Unit / Module 4 Acoustic Transduction**	**Learning Unit / Module 5 SONAR Application**
		9	**9**	**9**	**9**	**9**
S-1	SLO-1	*Introduction to SONAR equation,*	*Processing ocean sound-Sampling rules*	*Reverberation-Scattering, back scattering strength and target strength*	*Piezoelectric transducer-Introduction*	*Echo sounder*
	SLO-2	*Source Intensity, Source Directivity*	*Spatial sampling and Temporal sampling*	*Surface and bottom scattering*	*Piezoelectric transducer-33-Mode longitudinal vibrator*	*Echo Sounder*
S-2	SLO-1	*Transmission loss*	*Filter operations-Finite Fourier transformation*	*Volume scattering, bottom scattering, reverberation target strength*	*Piezoelectric transducer-33-Mode longitudinal vibrator*	*Sub-bottom profiling*
	SLO-2	*Transmission loss*	*Filter operations-Time domain view of Band pass filtering. convolution operations, frequency domain*	*Calculation of reverberation for use in the sonar equation, Volume reverberation level*	*Electrostrictive transducers*	*Fishing sonars*
S-3	SLO-1	*Target Strength*	*Gated Signals-Dependence of Spectrum on ping carrier periodicity*	*Reverberation frequency spread and Doppler gain potential-Power spectral density of a CW pulse*	*Electrostrictive transducers*	*Side scan terrain mapping sonar*
	SLO-2	*Reflection Intensity Loss Coefficient*	*Power spectra of random signal-Signal having random characteristics, Spectral density,*	*Environmental frequency sampling*	*Magnetostrictive transducers*	*Side scan terrain mapping sonar*
S-4	SLO-1	*Sea-floor Loss,*	*Radom signal simulations-Intensity spectral density, Spectral smoothing*	*Frequency spreading due to transmitter and receiver motion*	*Magnetostrictive transducers*	*Acoustic positioning and navigation*
	SLO-2	*Sea-surface Loss*	*Matched filters and autocorrelation*	*Frequency spreading due to target, important observation with respect to reverberation*	*Electostatic Transducers*	*Acoustic positioning and navigation*

S-5	SLO-1	*Noise, Reverberation*	*Sounds in the oceans-natural physical sounds and biological sounds*	*Noise-Ambient noise models*	*Electostatic Transducers*	*3D Imaging Processing-data model*
	SLO-2	*Active and Passive Sonar Equations*	*Sound propagation in the ocean and underwater acoustic channel-Sound wave and vibration, velocity of sound*	*Ambient noise-seismic noise, ocean turbulence, shipping noise*	*Variable Reluctance Transducers*	*3D Imaging Processing-acquisition of 3D information*
S-6	SLO-1	*Passive Sonar Equations, Signal-to-Noise Ratio*	*Sound propagation in the ocean and underwater acoustic channel-Sound wave velocity of sound*	*Wave noise, thermal noise*	*Variable Reluctance Transducers*	*3D Imaging Processing-matrix approach and real time systems*
	SLO-2	*Signal Excess, Figure of Merit*	*Wave and ray theories of underwater sound fields*	*Rain noise, temporal variability of ambient noise, depth effects of noise*	*Moving coil transducers*	*3D Imaging Processing-Image representation, Acoustic image processing*
S-7	SLO-1	*Active SONAR target strength*	*Wave and ray theories of underwater sound fields*	*Under ice noise*	*Moving coil transducers*	*3D Imaging Processing-Segmentation and reconstruction of underwater tubular structures*
	SLO-2	*Active SONAR- reverberation, detection threshold*	*Wave and ray theories of underwater sound fields*	*Spatial coherence of ambient noise*	*Equivalent circuits-Basics Circuit Resonance*	*3D Imaging Processing-Segmentation and reconstruction of underwater tubular structures*
S-8	SLO-1	*Active Sonar Sources- Source Level, Cavitation*	*Sound absorption in sea water and its characteristics*	*Self-noise-Flow noise*	*Circuit Q and Bandwidth*	*Acoustic communication-Cross attributes of the received signal*
	SLO-2	*Near-Field Interactions Explosive Sources*	*Upper boundary of acoustic channel*	*Self-noise – Flow noise*	*Transducers as projectors-principle*	*Acoustic communication-channel transfer function*
S-9	SLO-1	*Physics of Shock Waves in Wate, Bubble Pulses*	*Lower boundary of acoustic channel and its characteristics*	*Self noise-turbulent noise coherence*	*Transducers as Hydrophones-principles of operations*	*Acoustic communication-combating multipath*
	SLO-2	*Pros and Cons of Explosive Charges, Parametric Acoustic Sources*	*sound field in shallow water*	*Self noise-strumming noise*	*Transducers as Hydrophones-simplified equivalent circuit*	*Acoustic communication-diversity reception, equalization*

Learning Resources	1. Richard P HODGES, "Underwater Acoustics – Analysis, Design and Performance of SONAR", Wiley 1 edition2010, ISBN 978-0-470-68875- 2. Rodney F W Coates, "Underwater Acoustics Systems", Macmillan New Electronics,Wiley, 1st edition , 1990, ISBN 978-0-333-42542-8 3. Robert S H Istepanian and MilicaStojanovic, "Underwater Acoustic Digital Signal Processing and Communication Systems", Springer, 2002 edition, ISBN 978-1-4419-4882-3	4. Charles H Sherman, John L Butler, "Transducers and Arrays for Underwater Sound", Springer; 2nd edition, 2016, ISBN-10: 0-387-32940-4 ISBN-13: 978-0387-32940-6 5. Qihu Li, "Digital Sonar Design in underwater acoustics: Principles and applications", Springer, Zhejang University Press, 2012 6. Herman Medwin, Clarence S.Clay, "Fundamentals of Acoustical Oceanography", Academic Press, 1998.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO106J	Course Name	PCB Design and Manufacturing	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards			

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Explore the terminologies of PCB design and Electronic components.
CLR-2 :	Understand the design and other consideration involved in PCB design
CLR-3 :	Understand the PCB design consideration for special application circuits
CLR-4 :	Design a PCB layout using CAD tool
CLR-5 :	Explore various PCB manufacturing techniques
CLR-6 :	

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Identify the various types of PCB and electronics components packaging	1	80	70
CLO-2 :	Select suitable design and consider appropriate parameters involved in PCB design	1,2	80	70
CLO-3 :	Apply the appropriate design rules in designing PCB for special application circuits	1,2	80	70
CLO-4 :	Design and develop a PCB layout using CAD tool	1,2, 3	80	70
CLO-5 :	Identify and select the required PCB manufacturing technology	1,2, 3	80	70
CLO-6 :				

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO–1: Professional Achievement	14 PSO – 2: Project Management Techniques	15 PSO – 3: Analyze & Research
CLO-1 :	H			L											
CLO-2 :	M		L												
CLO-3 :	M			L											
CLO-4 :	M			M	H										
CLO-5 :	L				H										
CLO-6 :															

		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
Duration (hour)		12	12	12	12	12
S-1	SLO-1	Nomenclature of a Printed Circuit Board	PCB Design Considerations - Important Design Elements	Design Rules for Analog Circuits	Schematic Capture - Introduction schematic capture tool	Image Transfer Techniques- Screen Printing, Pattern Transferring Techniques
	SLO-2	Classification of Printed Circuit Boards	PCB Design Considerations - Important Performance Parameters			
S-2	SLO-1	Manufacturing of basic PCB - Single-and Double-sided Plated Through-holes	PCB Design Considerations - Mechanical Design Considerations	Design Rules for Digital Circuits	Schematic Capture - Simulation of simple electronic circuit	Image Transfer Techniques- Printing Inks, Photo Printing, Laser Direct Imaging (LDI)
	SLO-2	Manufacturing of Multi-layer Boards - Flexible Boards, Challenges in modern PCB Design and Manufacture, PCB Standards	PCB Design Considerations - Mechanical Design Considerations		Schematic Capture - Schematic to layout transfer	Copper Clad Laminates - Properties of Laminates, Types of Laminates, Evaluation of Laminates
S-3	SLO-1	Study of electronic components- Passive electronic components	Design and analysis of RL and RC time constants. Schematic in CAD tool	Schematic and PCB Layout in CAD tool. **Regulated power supply design.- Full wave rectifier circuit design with fixed voltage regulator**	**PCB Layout Design of single digit pulse counter using PCB design tool.**	**Mini Project - PCB Layout Design of electronic turn ON/OFF timer using IC555 using PCB design tool.**
	SLO-2					
S-4	SLO-1					
	SLO-2					
S-5	SLO-1	Types, Symbols, Packaging shapes and terminal details of Electronic Components –Resistors, Thermistors Capacitors, Inductors	PCB Design Considerations - Electrical Design Considerations	Design Rules for High Frequency Circuits	PCB Layout Design - Conception Level Introduction	Etching Techniques – wet Etching chemicals
	SLO-2	Diodes, Light Emitting Diodes (LED), Photodiode,	PCB Design Considerations - Conductor Patterns, Component Placement Rules	Design Rules for Fast Pulse Circuits	PCB Layout Design - Specifying Parts, Packages and Pin Names, Libraries	Etching Techniques - Mechanical Etching
S-6	SLO-1	Transistors, Field-effect Transistors, Insulated Gate Bipolar Transistor (IGBT), Thyristor	Fabrication and Assembly Considerations	Design Rules for Microwave Circuits	PCB Layout Design - Checking foot prints of the components, Part list, Net list, Making Net list Files	PCB Assembly Process - Through-hole
S-7	SLO-1		Design and analysis of RLC circuits. Schematic in CAD tool	Schematic and PCB Layout in CAD tool.		**Mini Project - Manufacture the PCB for electronic turn ON/OFF timer using**
	SLO-2					

S-8	**SLO-1**	*Study of electronic components- active devices, analog and digital integrated circuits (IC)*		***Regulated power supply design. -Full wave rectifier circuit design with fixed voltage regulator***	***PCB Design of single digit pulse counter: Schematic and PCB layout using PCB design tool.***	***IC555and construct and test the designed circuit.***
	SLO-2					
S-9	**SLO-1**	*Digital Integrated Circuits, Random Access Memory*	*Environmental Factors, Cooling Requirements*	*Design Rules for High-density Interconnection Structures*	*PCB Layout Design - Mounting Holes, Adding Text, PCB Layout*	*PCB Assembly Process - Surface Mount, Mixed Technologies*
	SLO-2	*Read Only Memory*	*Packaging Density*			
S-10	**SLO-1**	*Microcontrollers, Surface Mount Devices*	*Layout Design*	*Electromagnetic Interference/Compatibility (EMI/EMC)*	*PCB Layout Design - DRC, Pattern Transfer, Layout printing*	*PCB Assembly Process - Soldering*
	SLO-2	*Transformer, Relays, Connectors*				
S-11	**SLO-1**	*Study of testing and measuring Instruments: Logic analyzer, spectrum analyzer, IC tester (Analog and Digital), LCR meters*	*PCB Layout Design - of RL, RC and RLC circuits*	*Schematic and PCB Layout in CAD tool.* ***Regulated power supply design. Full wave rectifier circuit design with fixed voltage regulator***	***Mini Project - PCB Layout Design of electronic turn ON/OFF timer using IC555 using PCB design tool.***	***Mini Project - Manufacture the PCB for electronic turn ON/OFF timer using IC555and construct and test the designed circuit.***
	SLO-2					
S-12	**SLO-1**					
	SLO-2					

Learning Resources

1. *Raghbir Singh Khandpur, "Printed Circuit Boards: Design, Fabrication, and Assembly" McGraw-Hill Electronic Engineering, 2006.*
2. *Charles A. Harpe, "High Performance Printed Circuit Boards", McGraw Hill Professional, 2000.*
3. *Bruce R. Archambeault, James Drewniak, "PCB Design for Real-World EMI Control", Volume 696 of The Springer International Series in Engineering and Computer Science, Springer Science & Business Media, 2013.*
4. *Kraig Mitzner, "Complete PCB Design Using OrCAD Capture and PCB Editor", Newnes/Elsevier, 2009.*
5. *Douglas Brooks "Signal Integrity Issues and Printed Circuit Board Design", Prentice Hall PTR, 2003.*
6. *Mark I. Montrose "Printed Circuit Board Design Techniques for EMC Compliance : A handbook for designers" Wiley, 2 Edition, 2015.*
7. *Esim open source tool : http://esim.fossee.in/*
8. *TINA/Orcad User manual*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO107T	Course Name	Fiber Optics and Optoelectronics	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Analyze the basic laws and theorems of light associated with the optical fiber communication and the classification of optical fibers
CLR-2 :	Address concepts related to transmission characteristics such as attenuation and dispersion.
CLR-3 :	Explore the fundamentals of optoelectronics display devices, Sources and Detectors
CLR-4 :	Gain to information on Optical modulators and amplifiers
CLR-5 :	Illustrate the integration methods available for optoelectronic circuits and devices
CLR-6 :	Utilize the basic optical concepts applied in various engineering problems and identify appropriate solutions

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Review the basic theorems related to fiber optic communication, and attain knowledge of types of optical fibers	2	80	70
CLO-2 :	Understand the optical signal distortion factors in optical fiber communication	2	85	75
CLO-3 :	Familiarize the principle and operation of various display devices, light sources and detectors	2	75	70
CLO-4 :	Acquire knowledge of various optoelectronic modulators and amplifiers	2	85	80
CLO-5 :	Understand the various optoelectronic integrated circuits	2	85	75
CLO-6:	Acquire fundamental concepts related to optical communication and optoelectronic devices	2	80	75

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO–1: Professional Achievement	14 PSO – 2: Project Management Techniques	15 PSO – 3: Analyze & Research
CLO-1 :	H	H	-	-	-	-	-	-	-	-	-	-	-		H
CLO-2 :	H	-	M	-	-	-	-	-	-	-	-	-	-	-	M
CLO-3 :	H	M	M	-	-	-	-	-	-	-	-	-	-	-	L
CLO-4 :	H	-	M	-	-	-	-	-	-	-	-	-	-	-	H
CLO-5 :	H	-	M	L	-	-	-	-	-	-	-	-	-	-	L
CLO-6:	H	M	M	L	-	-	-	-	-	-	-	-	-	-	H

Duration (hour)		Learning Unit / Module 1 Introduction to Optical Fibers	Learning Unit / Module 2 Transmission Characteristics of Optical Fibers	Learning Unit / Module 3 Display Devices, Light Sources and Detection Devices	Learning Unit / Module 4 Optoelectronic Modulators and Switching Devices	Learning Unit / Module 5 Optoelectronic Integrated Circuits
		9	9	9	9	9
S-1	SLO-1	Evolution of fiber optic system	Attenuation – Absorption, Attenuation units	Display devices – Photo luminescence	Analog and Digital Modulation	Optoelectronic integrated circuits - Introduction
	SLO-2	Elements of an optical fiber transmission link	Attenuation – Scattering losses	Cathode luminescence	Electro optic modulators – Electro optic effect – Longitudinal electro optic modulator	Need for Integration - Hybrid and Monolithic Integration
S-2	SLO-1	Elements of an optical fiber transmission link	Attenuation – Bending losses, microbending and macro bending losses	Electro luminescence	Electro optic modulators – Transverse electro optic modulator	Hybrid and Monolithic Integration
	SLO-2	Advantages of fiber optic system	Attenuation - Core cladding losses	Injection luminescence	Acousto optic modulators – Transmission type – Raman Nath modulator	Materials and processing of OEICs
S-3	SLO-1	Characteristics and behavior of light	Signal distortion in optical waveguides	Light source materials	Acousto optic modulators – Reflection type – Bragg modulator	Application of optoelectronic integrated circuits
	SLO-2	Total internal reflection	Types of dispersion-Intramodal and Intermodal dispersion	Surface emitting LEDs	Solving Problems	Slab and Strip Waveguides
S-4	SLO-1	Acceptance angle	Material dispersion	Edge emitting LEDs	Optical switching and logic devices – self-electro-optic-device	Integrated transmitters and receivers – Front end photo receivers
	SLO-2	Numerical aperture, Critical angle	Material dispersion, Waveguide dispersion	Quantum efficiency and LED power – Internal quantum efficiency derivation	Optical switching and logic devices – Bipolar controller modulator	Integrated transmitters and receivers – photoreceiver noise and bandwidth considerations

S-5	**SLO-1**	*Solving Problems*	*Waveguide dispersion*	*Quantum efficiency and LED power – External quantum efficiency and total LED power*	*Optical switching and logic devices- tunable threshold logic gate – Switching speed and energy.*	*Integrated transmitters and receivers – PIN-HBT photoreceivers*
	SLO-2	*Solving Problems*	*Signal distortion in single mode fibers*	*Solving Problems*	*Optical Amplifiers – General applications of optical amplifiers*	*Integrated transmitters and receivers – OEIC transmitters – equivalent circuit for integrated receivers*
S-6	**SLO-1**	*Ray optics*	*Polarization mode dispersion*	*Semiconductor laser diode*	*Semiconductor optical amplifiers – Basic configuration*	*Integrated transmitters and receivers – Complex circuits and arrays*
	SLO-2	*Types of rays*	*Polarization mode dispersion, Intermodal dispersion*	*Modes and threshold condition*	*Semiconductor optical amplifiers – Optical gain - Limitations*	*Integrated transmitters and receivers - optical control and microwave oscillators*
S-7	**SLO-1**	*Optical fiber modes*	*Intermodal dispersion*	*Photo detection principle*	*Erbium doped fiber amplifiers – energy level diagram and amplification mechanism*	*Guided wave devices – Waveguide and couplers*
	SLO-2	*Optical fiber configurations*	*Solving Problems*	*PIN Photodiode*	*Erbium doped fiber amplifiers – EDFA configuration*	*Guided wave devices – Active guided wave devices*
S-8	**SLO-1**	*Single mode fibers*	*Solving Problems*	*PIN photodiode - Avalanche Photodiode*	*Solving Problems*	*Guided wave devices – Mach Zehnder Interferometers*
	SLO-2	*Multimode Fibers*	*Pulse Broadening in Graded Index Waveguides*	*Avalanche Photodiode*	*Solving Problems*	*Active couplers*
S-9	**SLO-1**	*Step Index Fibers*	*Mode Coupling*	*Noise mechanism in photodetectors*	*Fiber Raman Amplifiers – Configuration – Forward pumping*	*Active Couplers*
	SLO-2	*Graded Index Fibers*	*Design Optimization of Single Mode Fibers*	*Solving Problems*	*Fiber Raman Amplifiers – Backward pumping*	*Active Couplers*

Learning Resources	1. *Gerd Keiser, "Optical Fiber Communications", 5th Edition, McGraw Hill Education (India), 2015.* 2. *Khare R P, "Fiber Optics and Optoelectronics", Oxford University Press, 2014.*	3. *J. Wilson and J. Hawkes, "Optoelectronics – An Introduction", Prentice Hall, 1995.* 4. *Pallab Bhattacharya, "Semiconductor Optoelectronic Devices", Prentice Hall of India Pvt. Ltd, 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.aniii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. S. Sathiyan, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO108J	Course Name	EMBEDDED SYSTEM DESIGN USING ARDUINO	Course Category	O	Open elective courses	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	ECE	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Get to know about ARDUINO hardware details and environment
CLR-2 :	To understand the core elements of ARDUINO programming language
CLR-3 :	Create insights to the concepts of serial communication
CLR-4 :	To use common input and output devices
CLR-5 :	Apply the ARDUINO programming into real time applications
CLR-6 :	

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Analyze the programming skill	2	80	70
CLO-2 :	Apply the real time data's into digital	2	85	75
CLO-3 :	Interact with almost many devices	2	75	70
CLO-4 :	Learn techniques to handle timer delays and IO devices	2	85	80
CLO-5 :	Use and modifying the existing libraries	2	85	75
CLO-6 :				

	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	H		-	-	-	-	-	-	-	-	-	-	-	H	H
CLO-2 :	H	H	H	H	H	-	-	-	H	-	H	-	-	H	H
CLO-3 :	H	-	H	H	H	-	-	-	H	-	H	-	H	H	-
CLO-4 :	H	H	H	H	H	-	-	-	H	-	H	-	H	H	-
CLO-5 :	H	-	H	H	H	-	-	-	H	-	H	-	H	H	-

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction to arduino platform	Introduction To Arduino C	Analog And Serial Communication	IO Programming	Case Studies
	SLO-2	Block diagram	Arduino C Data Types .	Introduction To Analog Communication	Introduction To Timer/Counters	Wireless Communication Using Zigbee
S-2	SLO-1	AT mega 328p architecture	Decision Making in C	Pulse Width Modulation	Introduction To Timer/Counters	Bluetooth
	SLO-2	AT mega 328p architecture	Decision Making in C	RS232	Timer programming	Robotics -Motor And Sensor
S 3-4	SLO-1	Lab 1 Getting Started With Adriano	Lab 4 -Sensor Interfacing For Temperature Monitoring	Lab 7: Actuators – Stepper Motor	Lab10:Interrupt Programming	Lab 13:Mini Project
	SLO-2	CCS And AVR Studio 7 Blinking Led	Lab 4 -Sensor Interfacing For Displacement Measurement	Lab 7: Actuators – Stepper Motor	Lab10:Interrupt Programming	Lab 13:Mini Project
S-5	SLO-1	Pin function	Program Loops in C	I2C	Timer programming	Security-RFID, Infrared
	SLO-2	Overview of main features-I/O ports	Functions in C	I2C	Timer programming	Security-RFID, Infrared
S-6	SLO-1	Features-timers,interrupts	Introduction to Pointers	I2C	Timer programming	Bio medical application
	SLO-2					
S 7-8	SLO-1	Lab 2 GPIO LED	Lab 5: PWM BASED SERVO MOTOR INTERFACING	Lab 8: DC MOTOR	Lab11:Watch Dog Timer	Lab14:Model Practical
	SLO-2	Switch Based Led Control	Lab 5: PWM Based Servo Motor Interfacing	Lab 8: DC MOTOR	Lab11:Watch Dog Timer	Lab14:Model Practical
S-9	SLO-1	Features-PWM,SERIAL PORT	Using Pointers Effectively	SPI Protocol	Interrupts	Bio medical application

	SLO-2	*Features-ADC*	*Structures, Unions, and Data Storage*	*SPI Protocol*	*Interrupt programming*	*Bio medical application*
S-10	**SLO-1**	*Introduction to Arduino IDE*	*Arduino Libraries*	*Interfacing with sensors*	*External interrupt*	*GPS Navigation*
	SLO-2	*Writing ,saving,compiling with IDE.*	*Arduino Libraries*	*Interfacing with sensors*	*External interrupt*	*GPS Navigation*
S11-12	**SLO-1**	*Lab 3:DISPLAY INTERFACE-7 SEGMENT*	*Lab 6:SERIAL COMMUNICATION*	*Lab 9: Repeat/Revision Of Experiments*	*Lab 12 : I2C*	*Lab:15 University Practical*
	SLO-2	*LCD 16x2 Matrix*	*Lab 6:Serial Communication*	*Lab 9: Repeat/Revision Of Experiments*	*Lab 12: I2C*	*Lab:15 University Practical*

Learning Resources	1. Michael-Margolis,Arduino-Cookbook., Revised edition, O'Reilly,1st edition, 2011 2. D.Dale.Wheat, Arduino.Internals, TIA publication, 5th edition, 2011	3. James M. Fiore, Embedded Controllers Using C and Arduino, ARDUINO open source community, 2018 4. Jack Purdum ,Beginning C for Arduino , Apress, 2012

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Anuj Kumar, Bombardier* Transportation, Ahmedabad, *kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor* of ECE, CEG, Anna University, *meena68@annauniv.edu*	*1.Mrs. S. Suhasini,, SRM IST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO109J	Course Name	Embedded System Design using Raspberry Pi	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understanding the programing of python for Raspberry Pi			
CLR-2 :	Applying python programming on GPIO and interfacing motors using Raspberry Pi			
CLR-3 :	Applying python programming on GPIO switch and keyboard			
CLR-4 :	Create insights to the concepts and programming of motion detection ,GPS programming, light sensor ,gas detection			
CLR-5 :	Analyze and understand the working principle and data sheet of temperature sensor, gas sensor ,ADC, ultrasonic rangefinder, Acceleration and light sensor			
CLR-6 :	Utilize the technology of node js ,cloud service and MQTT Protocol for moving sensor data to web			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research	
CLO-1 :	Apply python for Raspberry Pi	2	80	70	H	H	-	-	H	-	-	-	-	-	-	-	H	-	-	
CLO-2 :	Analyze data sheet and functioning of sensors	2	85	75	H	H	H	H	H	-	-	-	-	-	-	-	-	-	H	
CLO-3 :	Apply python programming on GPIO of Raspberry Pi and interfacing of sensor	2	75	70	H	H	H	H	-	-	-	-	-	-	-	-	H	-	-	
CLO-4 :	Apply python programming on GPIO of Raspberry Pi to interfacing of actuators	2	85	80	H	H	H	H	H	-	-	-	-	-	-	-	H	-	-	
CLO-5 :	Apply python programming on GPIO of Raspberry Pi to interfacing input and display device	2	85	75	H	-	H	H	-	-	-	-	-	-	-	-	H	-	-	
CLO-6 :	Apply technology of node js ,cloud service and MQTT Protocol for IOT application	2	80	70	H	-	H	-	H	-	-	-	-	-	-	-	-	-	H	

Duration (hour)		Learning Unit / Module 1 Basic python programming	Learning Unit / Module 2 Programming interrupts –Motor control, switches and keyboard interface	Learning Unit / Module 3 Sensor interface and programming	Learning Unit / Module 4 Temperature sensor and display interface programming	Learning Unit / Module 5 Publishing sensor data on web service
		12	12	12	12	12
S-1	SLO-1	Python Basics- Editing Python Programs with IDLE, Variables, displaying Output, Reading User Input , Arithmetic, Creating Strings	Programming with Interrupts	Detecting Movement-PIR sensor	Measuring Temperature Using a Digital Sensor	publish sensor data on web service-building a home security dash board
	SLO-2	Concatenating (Joining) Strings, Converting Numbers to Strings, Converting Strings to Numbers ,Find the Length of a String, Find the Position of One String Inside Another, Extracting Part of a String, Replacing One String of Characters with Another Inside a String ,Converting a String to Upper- or Lowercase	Programming with Interrupts	Data sheet analysis of PIR sensor	Data sheet analysis Digital Temperature Sensor	publish sensor data on web service-building a home security dash board
S-2	SLO-1	Running Commands Conditionally, Comparing Values, Logical Operators,	Controlling GPIO Outputs Using a Web Interface	Adding GPS to the Raspberry Pi	Measuring Distance-ultrasonic rangefinder	MQTT Protocol
	SLO-2	Repeating Instructions an Exact Number of Times ,Repeating Instructions Until Some Condition Changes , Breaking Out of a Loop, Defining a Function in Python	Controlling GPIO Outputs Using a Web Interface	Data sheet analysis of GPS	Data sheet analysis ultrasonic rangefinder	MQTT Protocol- installation and setting account ,token creation ,reading sensor data and pushing to thingsboard

S-3-4	SLO-1	***Lab 1: Arithmetic and string***	***Lab 7: Programming on interrupts***	***Lab 13: Programming on PIR sensor***	***Lab 19: Programming on Digital Temperature Sensor***	***Lab 25: Publish sensor data on web service***
	SLO-2	***Lab 2: Loop***	***Lab 8: Programming on Web Interface***	***Lab 14: Programming on GPS***	***Lab 20: Programming on ultrasonic rangefinder***	***Lab 26: Publish sensor data on web service***
S-5	SLO-1	*Creating a List , Accessing Elements of a List, Find the Length of a List , Adding Elements to a List , Removing Elements from a List,*	*Controlling Servo Motors using PWM*	*Using Resistive Sensors*	*Logging to a USB Flash Drive*	*basic of java scripts –node.js*
	SLO-2	*Creating a List by Parsing a String, Iterating over a List, Enumerating a List, Sorting a List, Cutting Up a List. Applying a Function to a List*	*Controlling the Speed of a DC Motor*	*Measuring Light*	*Logging to a USB Flash Drive*	*Modules-HTML module*
S-6	SLO-1	*Creating a Dictionary ,Accessing a Dictionary, Removing Things from a Dictionary,*	*Controlling the Direction of a DC Motor*	*Detecting Methane*	*Using a Four-Digit LED Display*	*Modules –file –event*
	SLO-2	*Iterating over Dictionaries*	*Using a Unipolar Stepper Motor*	*Data sheet analysis of gas sensor*	*Displaying Messages on an I2C LED matrix with data sheet discussion*	*Modules –file –event*
S-7-8	SLO-1	***Lab 3: Program on list***	***Lab 9: Programming on Stepper Motor***	***Lab 15: Programming on light sensor***	***Lab 21: Programming on Four-Digit LED Display***	***Lab 27: Programming on node js HTML module***
	SLO-2	***Lab 4: Program on Dictionary***	***Lab 10: Programming on DC Motor***	***Lab 16: Programming on Gas sensor***	***Lab 22: Programming on I2C LED matrix***	***Lab 28: Programming on node js file and event module***
S-9	SLO-1	*Controlling Hardware-Connecting an LED-Controlling the Brightness of an LED*	*Using a Bipolar Stepper Motor*	*Measuring a Voltage using MCP3008 And data sheet of MCP3008*	*Displaying Messages on an Alphanumeric LCD*	*LED blinking using node.js*
	SLO-2	*a Buzzing Sound*	*Building a Simple Robot Rover*	*Using Resistive Sensors with an ADC*	*Displaying Messages on an Alphanumeric LCD*	*LED blinking using node.js*
S-10	SLO-1	*Switching a High-Power DC Device Using a Transistor*	*Digital Inputs-Connecting a Push Switch-Toggling with a Push Switch-Using a Two-Position Toggle or Slide Switch*	*Measuring Temperature with an ADC*	*Cloud service for IOT*	*building java script client using MQTT broker*
	SLO-2	*Switching a High-Power Device Using a Relay*	*Using a Rotary (Quadrature) Encoder and Using a Keypad*	*Measuring Acceleration and data sheet discussion of Acceleration sensor*	*Cloud service for IOT*	*building java script client using MQTT broker*
S-11, 12	SLO-1	***Lab 5: LED blinking and Brightness control***	***Lab 11: Programming on Switch***	***Lab 17: Programming on ADC***	***Lab 23: Programming on an Alphanumeric LCD***	***Lab 29: Programming on LED blinking using node.js***
	SLO-2	***Lab 6: Switching a High-Power DC Device***	***Lab 12: Programming on Keypad***	***Lab 18: Programming on Measuring Acceleration***	***Lab 24: Programming on an Alphanumeric LCD***	***Lab 30: Building java script client using MQTT broker***

Learning Resources	1. *Simon Monk, "Raspberry Pi Cookbook", O'Reilly Media, Inc, 2014.* 2. *Volker Ziemann, "A Hands-On Course in Sensors Using the Arduino and Raspberry Pi, CRC Press, 2018.*	3. *Colin Dow, "Internet of Thing: Programming Projects - Build modern IoT solutions with the Raspberry Pi 3 and Python", packtpub 2018.* 4. *https://thingsboard.io/docs/* 5. *https://www.w3schools.com/nodejs/nodejs_raspberrypi_blinking_led.asp*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18ECO110J	Course Name	3D Printing Hardware and Software	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the tools available for 3D printing
CLR-2 :	Familiarize with 3D design software and hardware
CLR-3 :	Understand the 3D design criteria and its limitations.
CLR-4 :	Learn the contemporary technology available for 3D design and printing
CLR-5 :	Understand various post processing methods involved in 3D printing technology
CLR-6 :	Develop the skillset on 3D component design and development using contemporary commercial software and hardware available.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Apply the 3D printing tools for components design	1	80	60
CLO-2 :	Able to optimistically select the 3D design software and hardware for the given problem	1	80	60
CLO-3 :	Capability to solve 3D design components design problems	2	75	60
CLO-4 :	Choose the contemporary technology available for 3D design and printing	3	80	60
CLO-5 :	Apply various post processing methods involved in 3D printing technology	2	80	60
CLO-6 :	Ability to develop the skillset on 3D component design and development using contemporary commercial software and hardware available.	2	80	60

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO–1: Professional Achievement	14 PSO – 2: Project Management Techniques	15 PSO – 3: Analyze & Research
CLO-1 :	M				M										
CLO-2 :	M				H										
CLO-3 :	M			M										M	
CLO-4 :			M											M	L
CLO-5 :		H													
CLO-6 :											M			M	

Duration (hour)		Introductions to 3D design tools	Three-dimensional (3D) Modeling	3D Design Fundamentals and Projects	3D Printing and its Technologies	Post Processing - Product Visualization and Print Cleaning
S-1	SLO-1	Introduction to Maya GUI - Object creation workflow, Constructing object primitives to scale and with accuracy	An overview of CAD software packages - Introduction to Fusion 360 - Drawing based workflow, Drawing constraints - Surfacing operations.	The good, the bad, and the ugly of design	History of 3D printing - Overview of 3D Printing technologies	Workflows for printing
	SLO-2					
S-2	SLO-1	Duplication and arrayed duplication - Grid and point/vertex snapping	Moving Parts and Articulation Hinges - Ball and sockets	Prominent Designers	Selective Laser Sintering (SLS) Direct Metal Laser Sintering (DMLS)	Software and Drivers - Formats for Printing (SLA, OBJ, CAD, etc.)
	SLO-2					
S 3-4	SLO-1	Understanding NURBS: NURBS Surfaces advantages, Similarities and differences between NURBS and CAD drawings Curve and surface construction	Creating a part negative, Creating Text in Maya the proper way (NURBS Curves, surface lofts, conversion to polygon) Painterly tools (Sculpt Geometry Tool, etc.)	Franchises Success stories, Pop culture	Vacuum forming - Resin casting - Injection Molding - Terms and standards for injection molding systems	Post and Export Print Lab setup
	SLO-2					
S-5	SLO-1	Understanding 3D geometry - Modeling workflows for Polygons - Additive vs. Subtractive Tools - Mesh editing	Flexibility and elasticity, Locks, bolts, and fasteners Threading (taps and dies)	Early decision making criteria	Fused Deposition Modeling (FDM) - Stereolithography (SLA)	Cleanup and airtight modeling
	SLO-2					
S-6	SLO-1	Best Practices for constructing printable polygon meshes	Interfacing, support, and reinforcement	Knowing the product	Laminated Object Manufacturing (LOM) - Electron Beam Melting (EBM)	Loading models and arranging print stage
	SLO-2	Fundamental Structure - Combining, merging, and sewing up polygon meshes				

S 7-8	SLO-1	*Best Practices for constructing printable polygon meshes - Fundamental Structure - Combining, merging, and sewing up polygon meshes*	*How the modeling software packages differ from CAD packages, Sketch/drawing based workflows, Similarities and differences between CAD and NURBS.*	*Brainstorming and critique in the early design phase Group critiques of in-progress projects*	*Printing Resolutions and Tolerances Materials Properties (Temperature, Flexibility, Strength, Brittleness)*	*Printing - Removing support material*
	SLO-2					
S-9	SLO-1	*Understanding two-manifold vs. non-manifold geometry*	*Form and function visualizing the assembly process*	*Early decision-making criteria Knowing the product Vision and Reality*	*3D Printing (3DP) – Selective laser melting (SLM)*	*Special topics – 3D Scanners and its types*
	SLO-2	*Exporting geometry - Laying out a simple model on a stage for print*				
S-10	SLO-1	*Hollow forms and the importance of reducing volume Cost of size, cost of volume, cost of detail, cost of time State table*	*Complex interactions and motorizations*	*Calculating the total cost Progress checks and group critiques of in-progress projects*	*Final cleanup and processing of files for printing*	*Reverse engineering, Concepts and its hardware and software*
	SLO-2					
S 11-12	SLO-1	*Clean and uniform topology, Illustrator, IGES, and other import/export pipelines*	*Broad overview of manufacturing techniques Molding, sculpting, lathing, lofting, welding, cutting, drilling, gluing, etc*	*Brainstorming and critique in the early design phase Group critiques of in-progress projects*	*Planning for injection molding - 3D Printing for injection molding*	*High speed machining*
	SLO-2					

Learning Resources	1. *Hod Lipson, Melba Kurman, Fabricated: The New World of 3D Printing, Wiley, 2013* 2. *Matthew Griffin, Design and Modeling for 3D Printing, Maker Media, Inc., 2013.* 3. *Rob Thompson, Manufacturing Processes for Design Professionals, Thames & Hudson; Reprint edition, 2007.* 4. *https://web.stanford.edu/class/me137/* 5. *SolidWorks Gallery: http://www.3dcontentcentral.com/default.aspx*	6. *3D Anatomy Models: http://lifesciencedb.jp/bp3d/?lng=en* 7. *AutoDesk Fusion360 HomePage: http://fusion360.autodesk.com* 8. *International Journal of Rapid Manufacturing* 9. *Academic Journals on 3D Printing* 10. *International Journal of Rapid Manufacturing*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Anuj Kumar, Bombardier* Transportation, Ahmedabad, *kumaranuj.anil@gmail.com*	1. *Dr. Meenakshi, Professor* of ECE, CEG, Anna University, *meena68@annauniv.edu*	1. Mr. S. Karuppudaiyan, Mechanical, SRMIST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. P. Eswaran, SRMIST*

Course Code	18ECO121T	Course Name	BASIC BIOMEDICAL ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Analyze the scopes and roles of Biomedical Engineering
CLR-2 :	Utilize biomedical instrumentation modules
CLR-3 :	Utilize medical imaging principles and its applications
CLR-4 :	Analyze the scope of biomechanics and its applications
CLR-5 :	Utilize biomaterials and its applications
CLR-6 :	Gain the knowledge about Biomedical Engineering

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 (Level of Thinking (Bloom))	Learning 2 (Expected Proficiency (%))	Learning 3 (Expected Attainment (%))	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO-1: Problem Solving at the interface of Engg. & Medicine	PLO 14 PSO-2: Design & Develop Medical Devices	PLO 15 PSO-3: multidisciplinary research for health care solu
CLO-1 :	Analyze the areas in which biomedical engineers can work	2	85	75	-	-	-	-	-	-	-	-	-	-	-	L	-	-	L
CLO-2 :	Analyze the basic biomedical instrumentation unit	3	85	75	L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-3 :	Analyze basic medical imaging principles	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Apply the concepts of biomechanics on human body	3	85	75	L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-5 :	Identify domains where biomedical engineers can work	3	85	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Analyze the applications of Biomedical Engineer	3	85	75	M	-	-	-	-	-	-	-	-	-	-	L	-	-	L

Duration (hour)		Introduction to Biomedical Engineering	Biomedical Instrumentation	Medical Imaging system	Biomechanics	Biomaterials
		9	9	9	9	9
S-1	SLO-1	Evolution of the modern health care system	Introduction: Bioinstrumentation	X-Ray production	Introduction: Principal Areas of Biomechanics	Biomaterials Introduction
	SLO-2	Modern Healthcare system	Basic Bioinstrumentation System	X-Ray Imaging principle	Fundamentals of biomechanics and qualitative analysis	Classification of Biomaterials
S-2	SLO-1	What is Biomedical Engineering	Physiological Systems of the body	Application of X-ray imaging	Kinematics of Human Body Models	Properties of Biomaterials: Mechanical
	SLO-2	Roles played by the Biomedical Engineers	Sources of Biomedical Signals	CT-Imaging principle	Kinetics of Human Body Models	Properties of Biomaterials: Chemical
S-3	SLO-1	Types of Biomedical Engineering	Origin of Bioelectric Signals	CT-Imaging Applications	Modelling of Bio systems	Properties of Biomaterials: Biological
	SLO-2	Surgical instruments and medical devices	Origin of Bioelectric Signals	MRI- Introduction	Tissue Biomechanics	Biomedical alloys and its medical applications- titanium
S-4	SLO-1	Biomaterials	Various Electrodes used for picking the biomedical signals	MRI Imaging principles	Modelling in Cellular Biomechanics	Biomedical alloys and its applications- Stainless steel, Cobalt-Chromium alloys
	SLO-2	Biomechanics	Various Electrodes used for picking the biomedical signals	MRI Imaging principles	Fluid mechanics	Introduction to ceramics
S-5	SLO-1	Tissue Engineering	ECG Introduction	MRI Imaging Applications	Mechanics of the musculoskeletal system impact	Alumina, Zirconia
	SLO-2	Neural Engineering	ECG system Block diagram and its uses	Ultrasound basics	Mechanics of Blood Vessels	Titanium, Hydroxyapatite
S-6	SLO-1	Telehealth	EEG Introduction	Ultrasound Imaging	Cardiac Biomechanics	Glass ceramics

	SLO-2	*Bio signal processing*	*EEG system Block diagram and its uses*	*Ultrasound Application*	*Biomechanics of Chest and Abdomen*	*Introduction to polymers*
S-7	**SLO-1**	*Medical Imaging*	*EMG Introduction*	*fMRI Imaging*	*Cochlear Mechanics*	*Types of polymers*
	SLO-2	*Computational modelling*	*EMG system Block diagram and its uses*	*fMRI Imaging Application*	*Dynamics of Human Body Models*	*Biodegradable polymers and its applications*
S-8	**SLO-1**	*BioMEMS*	*Cardiac pacemakers and its uses*	*PET- Imaging*	*Gait analysis*	*Composites and its applications*
	SLO-2	*Mobile POCT*	*Cardiac Defibrillators and its uses*	*PET Imaging Application*	*Biomechanics in physical education*	*Wound-Healing process*
S-9	**SLO-1**	*Professional Status of Biomedical Engineering*	*Patient Monitoring System Introduction*	*SPECT Imaging*	*Biomechanics in strength and conditioning*	*Biomaterials for artificial valve, Ear*
	SLO-2	*Professional Societies*	*Patient Monitoring System Block diagram and its uses*	*SPECT Imaging Application*	*Biomechanics in sports medicine and rehabilitation*	*Biomaterials for artificial Skin, Eye*

Learning Resources	1. *Anthony Y. K. Chan, Biomedical Device Technology: Principles and Design, Charles C Thomas publisher, 2008* 2. *R.S Khandpur, Handbook of Biomedical Instrumentation, 3rd ed., McGraw Hill, 2014* 3. *Joseph J. Carr, John M.Brown, Introduction to Biomedical Equipment Technology, 4th ed., Pearson, 2002*	4. *John Enderle, Joseph Bronzino, Introduction to Biomedical Engineering, Academic Press, 2011* 5. *Andrew R Webb, Introduction to Biomedical Imaging, Wiley-IEEE Press, 2003* 6. *Sujata V. Bhat, Biomaterials, 2nd ed., Alpha Science International, 2005*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	***1. Ms.** Oinam Robita Chanu**, SRMIST***
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anil@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	***2. Dr. D. Kathirvelu, SRMIST***
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO122T	Course Name	HOSPITAL INFORMATION SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Utilize the planning and organizational activities of Hospitals
CLR-2 :	Analyze the concepts in clinical and diagnostic services
CLR-3 :	Utilize the policies and procedures about support services and material management
CLR-4 :	Utilize the features in staff and safety management in hospital
CLR-5 :	Analyze the reporting system and recent advancement in hospital administration
CLR-6 :	Apply all the advanced application the field of telemedicine

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Analyze the role of hospitals and ensure proper healthcare delivery	2	85	75	L	-	-	-	-	M	-	-	-	-	-	-	L	-	-
CLO-2 :	Suggest appropriate technologies and services in clinical and diagnostic field	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-3 :	Analyze the supportive services and the use of proper material management	3	85	75	M	-	-	-	-	-	M	L	-	-	-	-	M	-	L
CLO-4 :	Identify objectives of staff management and ensure safety management in hospitals	3	85	75	M	-	-	-	-	-	-	L	-	-	-	L	L	-	-
CLO-5 :	Implement the advance technologies and effectively evaluate the healthcare information	3	85	75	L	-	-	-	-	M	-	L	L	-	-	-	L	L	L
CLO-6 :	Implement the various standards in hospital and healthcare services	3	85	75	L	-	-	-	-	M	-	-	-	-	-	-	L	-	-

Duration (hour)		Planning and designing of hospitals	Inpatient and Outpatient services	Material management services	Management services in hospitals	Patient record and advancement in healthcare services
		9	9	9	9	9
S-1	SLO-1	Hospital as a social system	Design and planning of emergency department	Pharmacy services- goals of hospital pharmacy services	Human resource management- Human resource development	Medical record management- Importance of medical record
	SLO-2	Primary health care and hospitals	Health information and counselling	Staff organization and divisions of hospital pharmacy services	Hospital staff skill development	Methods of record keeping
S-2	SLO-1	Hospital planning and design-Guiding principles in planning	Outpatient services –Types and functions of outpatient department	Benefits of formulatory system	Nursing management-Functions of nursing management	Electronic medical record-Benefits and drawbacks
	SLO-2	Regionalization of Hospital service	Physical features of outpatient department	Other services of hospital pharmacy	Nursing management- organizational structure	Record retention and disposal
S-3	SLO-1	Role of health promotion approach in hospitals	Ward/Indoor services-Components of the ward system	Transport services-Types of ambulance	Biomedical waste management- Types and Composition of Biomedical Waste	Office management -skills required by the office staff
	SLO-2	Health promoting hospital system	Design of special units	Communication and physical facilities of ambulance service	Categories of biomedical waste	Functions of office management
S-4	SLO-1	Healthy hospital environment	Operation theatre services-Planning and designing of Operation theatres	Staff transport services	Concept of total quality management	Operations research in hospitals-Phases of operation research
	SLO-2	Components of healthy hospital environment	Types of Operation theatres	Other transport services in hospitals	Types of approaches in quality management	Operations research in hospitals- Tools and techniques of operations research

S-5	**SLO-1**	*Creating manpower services*	*Policies and procedures of operation theatres*	*Medicolegal services- Steps for Medicolegal Examination*	*Quality assessment and management tools*	*Emerging health insurance – components of health insurance*
	SLO-2	*Hospital engineering: Key to efficient healthcare services*	*Assessing operation theatre utilisation*	*Problems faced by healthcare professionals in medicolegal service*	*Clinical audit*	*Emerging health insurance-Types of health insurance*
S-6	**SLO-1**	*Designing disabled friendly hospitals-Barriers faced and implications in Persons with disabilities*	*Clinical laboratory services-Introduction and role of laboratory medicine*	*Food safety in hospitals-Need of food safety*	*Quality improvement-Cause and effect method*	*Advantages and common problems of health insurance schemes*
	SLO-2	*Need for disabled-friendly health services*	*Testing procedure in clinical laboratory*	*Sources of food contamination*	*Pareto analysis*	*Role of health and hospital administrators in Health insurance*
S-7	**SLO-1**	*Barrier-Free Environment to Universal Design*	*Radio diagnosis and imaging services-Planning and equipments of radiology department*	*Materials management- Principles of material management*	*Failure mode and effect analysis*	*Telemedicine clinic –functions and classification of telemedicine*
	SLO-2	*Overcoming the barriers*	*Advancement in radiology service*	*Concepts of Inventory control*	*Triggers of quality improvement strategy in a hospital*	*Challenges for telemedicine*
S-8	**SLO-1**	*Energy conservation- Classification*	*Radiation oncology service-Radiotherapy facilities*	*Modern techniques for inventory control*	*Occupational safety-Roles and responsibilities*	*Growth of mobile phones and potential of mobile health*
	SLO-2	*Types of energy streams in hospitals*	*Nuclear medicine services-Categorization and nuclear medicine department*	*Integrated concept for materials management*	*Prevention of hazards specific to health sector*	*Mobile health and its applications*
S-9	**SLO-1**	*Need for energy conservation*	*Planning of nuclear medicine department*	*Purchase and procurement system-Essentials for procurement process*	*Hospital security-Physical security*	*Challenges in implementing information and Communication technology in healthcare*
	SLO-2	*Energy conservation opportunities in hospitals*	*Ancillary requirements*	*Purchase system*	*Organizational chart of security wing*	*Information and communication technology applications in healthcare*

Learning Resources	1. *SonuGoel, Anil Kumar Gupta, Amarjeet Singh, Hospital administration A problem- solving approach, 1st ed., Elsevier, 2014*	2. *Sakharkar B M, Principles of hospital administration and planning, 2nd ed., Jaypee Brothers Medical Publishers, 2009* 3. *Kunders G D, Hospitals: Facilities planning and management, 1st ed., Tata Mcgraw Hill, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO123T	Course Name	BIOMEDICAL IMAGING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Utilize the working principle of X-ray imaging
CLR-2 :	Analyze the principle behind tomographic imaging and the reconstruction techniques
CLR-3 :	Interpret the theory behind nuclear medicine and utilize the working of imaging modalities in nuclear medicine
CLR-4 :	Analyze the physics of ultrasound and the different imaging modes using ultrasound
CLR-5 :	Utilize the physical principle of nuclear magnetic resonance and magnetic resonance image reconstruction
CLR-6 :	The learner will be to gain knowledge in the working principle of imaging modalities using X-ray, computed tomography, nuclear medicine, ultrasound and magnetic resonance imaging.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu.
CLO-1 :	Analyze the physics and principle behind the working of X-ray imaging	2	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	Identify the principle behind working of tomographic imaging and reconstruction procedures.	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Analyze the working principle of nuclear medicine imaging modalities	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-4 :	Identify the physics of ultrasound and the modes of ultrasound imaging	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	Explain the physical principle of magnetic resonance imaging and the instrumental components involved in MR imaging	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-6 :	Understand the basic principle and working of medical Imaging systems	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-

Duration (hour)		X-ray	Computed Tomography	Ultrasound	Magnetic Resonance Imaging	Nuclear medicine
		9	9	9	9	9
S-1	SLO-1	General principles of Imaging with X-rays	Introduction: Tomographic Imaging	Characteristics of sound: Propagation, wavelength, frequency and speed	Principles of NMR Imaging	Radionuclide decay terms and relationship
	SLO-2	X-ray Production –X-ray source	Comparison between tomographic and planar imaging	Pressure, Intensity and dB scale	Free Induction decay	Nuclear transformation
S-2	SLO-1	X-ray tube current, tube output	Basic principle: Technique of producing CT images	Interaction of ultrasound with matter: Acoustic impedance, reflection, refraction	Excitation, Emission	Radionuclide production
	SLO-2	Beam intensity, X-ray Energy Spectrum	Contrast scale	Scattering, Attenuation	Relaxation times-T1 & T2	Radiopharmaceuticals
S-3	SLO-1	Coherent and Compton scattering	System components: first generation, second generation, third generation,	Transducers: Piezoelectric materials, resonance transducers	Spin echo technique	Radiation detection and measurement: types of detectors, Gas-filled detectors
	SLO-2	Photoelectric effect	Fourth, fifth and spiral/helical CT	Damping block, matching layer, Resolution	Spin echo contrast weighting	Scintillation detectors
S-4	SLO-1	Linear and Mass attenuation coefficient of X-rays in tissue	X-ray source, types of detectors	Transducer arrays	T1 weighted image	Semiconductor detectors
	SLO-2	Instrumentation for Planar X-ray Imaging: Collimators	Gantry and slip ring technology, Collimation and filtration	Multi-element linear array scanners	T2 weighted image	Pulse height spectroscopy
S-5	SLO-1	Antiscatter grids Intensifying screens	Processing system	Multi-linear and phased array	Gradient recalled sequence	Non-imaging detector applications

	SLO-2	*X-ray films*	*Iterative reconstruction, back projection reconstruction*	*Generation and detection of ultrasound*	*Proton density weighted images, pulse sequence for fast imaging*	*Counting statistics*
S-6	**SLO-1**	*Instrumentation for computed and digital radiography*	*Filtered back projection*	*Basic pulse echo apparatus: A-scan*	*Slice selection gradient*	*Nuclear imaging*
	SLO-2	*X-ray Image characteristics: Signal to Noise ratio*	*Helical /Spiral CT: Helical pitch*	*B-Mode*	*Frequency encode gradient*	*Anger scintillation camera*
S-7	**SLO-1**	*Spatial resolution, Contrast to Noise ratio*	*Basic reconstruction approaches*	*M-mode*	*Phase encode gradient*	*Basic principle :Emission computed tomography*
	SLO-2	*X-ray contrast agents, X-ray angiography*	*Slice sensitivity profile*	*Echocardiograph*	*2D spin echo data acquisition*	*Single photon emission computed tomography*
S-8	**SLO-1**	*X-ray Fluoroscopy*	*Multislice CT*	*Duplex scanner*	*Basic NMR components: Main magnet, RF transmitter/receiver*	*Positron emission tomography*
	SLO-2	*X-ray mammography*	*Detector configuration*	*Intravascular imaging*	*Body coils, gradient coils*	*Imaging techniques and scanner instrumentation*
S-9	**SLO-1**	*Dual energy Imaging*	*Measurement of X-ray dosage*	*Artefacts: Refraction, shadowing and enhancement*	*fMRI : Basic principle*	*Dual modality: PET/CT*
	SLO-2	*Abdominal X-ray scans*	*Methods for dose reduction*	*Reverberation*	*BOLD concept, MR spectroscopy*	*Working and applications*

Learning Resources	*1. R.S.Khandpur, Handbook of Biomedical instrumentation, 3rd ed., Tata McGraw Hill, 2014*	*2. Jerrold T. Bushberg, John M. Boone, The essential physics of medical imaging, 3rd ed., Lippincott Williams & Wilkins, 2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	***1. Dr. T. Jayanthi, SRMIST***
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	***2. Dr. U. Snekhalatha, SRMIST***
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO124T	Course Name	HUMAN ASSIST DEVICES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Utilize the latest technology and device used for assisting human disability			
CLR-2 :	Analyze various devices used for mobility			
CLR-3 :	Utilize the various assist device used for hearing			
CLR-4 :	Utilize the various assist device used for vision			
CLR-5 :	Utilize the various assist device used in orthopaedic			
CLR-6 :	Analyze the working principles of cardiac assist devices and Artificial kidney			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Comprehend the assistive technology (AT) used for mobility	2	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	Analyze the Assist technology used for hearing	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	-	L	-
CLO-3 :	Evaluate the Assist technology used for sensory impairment of vision	3	85	75	-	-	-	-	-	-	-	-	-	-	-	-	-	L	-
CLO-4 :	Evaluate the assist device used in orthopedic	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	L	-
CLO-5 :	Analyze the latest use of assist technology in health care	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-6 :	Design the prosthetic heart valves and pacemaker	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Basic assessment and evaluation for mobility	Basic ear anatomy, Mechanism of hearing	Anatomy of eye	Anatomy of upper & lower extremities -	Basic Anatomy and physiology of heart.
	SLO-2	Basic assessment and evaluation for mobility	Common tests audiograms	Categories of visual impairment	Classification of amputation types	Cardiac assist devices
S-2	SLO-1	Manual wheelchairs	Air conduction, Bone conduction	Intraocular Devices	Prosthesis prescription	Intra-Aortic Balloon Pump (IABP),
	SLO-2	Electric power wheelchairs	Masking techniques,	Extraocular Devices	Hand and arm replacement	Prosthetic heart valves
S-3	SLO-1	Power assisted wheelchairs	SISI	Permanent Vision Restoration	Different types of models, externally powered limb prosthesis	Evaluation of prosthetic valve
	SLO-2	Wheel chair standards & tests -	Hearing aids principles	Non-Permanent Vision Restoration	Different types of models, externally powered limb prosthesis	Heart pacemaker
S-4	SLO-1	Wheel chair transportation	Drawbacks in the conventional unit	Voice Control Sound Control.	Foot orthosis	CABG
	SLO-2	Control systems, navigation in virtual space by wheelchairs	DSP based hearing aids	Sensor Technology Adapted for the Vision Impaired	Pediatric orthoses	Extracorporeal support
S-5	SLO-1	Wheel chair seating and pressure ulcers.	Cochlear Implants	Libraille	Wrist-hand orthosis	Vascular prosthesis
	SLO-2	EOG based voice controlled wheelchair	Internal Hearing Aid	GRAB	feedback in orthotic system	Vascular prosthesis
S-6	SLO-1	BCI based wheelchair	External Hearing Aid	mathematical Braille	Components of upper limb prosthesis	Artificial heart

	SLO-2	*Fuzzy logic expert system for automatic tuning of myoelectric prostheses*	*Permanent Hearing Restoration*	*Blind mobility aids*	*Components of lower limb prosthesis*	*Intermittent positive pressure breathing (IPPB) type assistance for lungs*
S-7	**SLO-1**	*Intelligent prosthesis*	*Non-Permanent Hearing Restoration*	*Reading writing & graphics access,*	*Lower extremity- and upper extremity-orthoses*	*Dialysis for kidneys*
	SLO-2	*Intelligent prosthesis*	*Touch Tactile Haptic Technology*	*Orientation & navigation Aids*	*Lower extremity- and upper extremity-orthoses*	*Artificial Kidney*
S-8	**SLO-1**	*Future trends in assistive technology*	*Sound Coding Translation*	*Wearable Assistive Devices for the Blind*	*functional electrical stimulation*	*Haemodialysis*
	SLO-2	*virtual reality based training system for disabled children*	*Acoustic Transducers Hearing Quality*	*Wearable tactile display for the fingertip.*	*Sensory assist devices*	*Membrane dialysis*
S-9	**SLO-1**	*Information technology, telecommunications,*	*Electric Electronic Stimulation*	*Cortical implants*	*Sensory assist devices*	*Portable dialysis monitoring and functional parameter*
	SLO-2	*new media in assisting healthcare*	*Hearing Enhancement*	*Retinal implants*	*Slints – materials used*	*Latest use of assistive technology for chronic heart diseases and healthcare*

Learning Resources

1. *Levine S.N. Advances in Bio-medical engineering and Medical physics, 1st ed., Vol. I, II, IV, Interuniversity publications, 1968.*
2. *Marion. A. Hersh, Michael A. Johnson, Assistive Technology for visually impaired and blind, 1st ed., Springer Science & Business Media, 2010*
3. *Kopff W.J, Artificial Organs, 1st ed., John Wiley and Sons, 1976*
4. *Daniel Goldstein, Mehmet Oz, Cardiac assist Devices, Wiley, 2000*
5. *Kenneth J. Turner, Advances in Home Care Technologies: Results of the match Project, 1st ed., Springer, 2011*
6. *Albert M.Cook, Webster J.G, Therapeutic Medical Devices, Prentice Hall Inc.,1982*
7. *Gerr .M. Craddock Assistive Technology-Shaping the future, 1st ed., IOS Press, 2003*
8. *Brownsell, Simon, et al,. A systematic review of lifestyle monitoring technologies, Journal of telemedicine and telecare 17.4 (2011): 185-189*
9. *Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph.D, Bronzino, Clinical Engineering, 1st ed., CRC Press, 2010*
10. *Pascal Verdonck, Advances in Biomedical Engineering, 1st ed., Elsevier, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO125T	Course Name	QUALITY CONTROL FOR BIOMEDICAL DEVICES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Utilize Quality, Quality control measures essential for an organization			
CLR-2 :	Utilize the quality management principles and good management practices			
CLR-3 :	Utilize the various quality control tools			
CLR-4 :	Utilize the various quality management tools			
CLR-5 :	Analyze the various standards applicable to healthcare globally and nationally			
CLR-6 :	Implement the global standards in healthcare			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Analyze the underlying concepts of quality and quality control concepts of an organization	2	85	75
CLO-2 :	Evaluate the various quality management principles and good management practices	3	85	75
CLO-3 :	Evaluate various tools of quality control	3	85	75
CLO-4 :	Analyze the various quality management tools	3	85	75
CLO-5 :	Analyze the various standards applicable to healthcare globally and nationally	3	85	75
CLO-6 :	Analyze the outcomes of implementing global standards	3	85	75

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	-	-	-	-	-	-	-	-	-	-	-	L	-	-	L
CLO-2 :	L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-3 :	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-5 :	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	M	-	-	-	-	-	-	-	-	-	-	L	-	-	L

Duration (hour)		Introduction to quality	TQM principles	Statistical process control	TQM tools	Quality systems
		9	9	9	9	9
S-1	SLO-1	Definition of Quality	Customer satisfaction – Customer Perception of Quality	The seven tools of quality	Benchmarking	ISO 9000 Systems
	SLO-2	Dimensions of Quality	Customer Complaints	Cause-and-effect diagram	Reasons to Benchmark	ISO 9000 Systems
S-2	SLO-1	Quality Planning	Service Quality	Check sheet	Benchmarking Process	ISO 9000:2000 Quality System – Elements
	SLO-2	Quality Planning	Customer Retention	Check sheet	Benchmarking Process	ISO 9000:2000 Quality System – Elements
S-3	SLO-1	Quality costs	Employee Involvement	Control chart	Quality Function Deployment (QFD)	Need for Accreditation of hospitals
	SLO-2	Quality costs	Motivation	Control chart	Quality Function Deployment (QFD)	Need for Accreditation of hospitals
S-4	SLO-1	Basic concepts of Total Quality Management	Empowerment	Histogram	House of Quality	FDA Regulations
	SLO-2	Principles of TQM	Teams and Team Work	Histogram	House of Quality	FDA Regulations
S-5	SLO-1	Leadership – Concepts	Recognition and Reward	Pareto chart	QFD Process - Benefits	Joint Commission
	SLO-2	Role of Senior Management	Performance Appraisal	Pareto chart	QFD Process - Benefits	Joint Commission
S-6	SLO-1	Quality Council	Juran Trilogy	Scatter diagram	Total Productive Maintenance (TPM) – Concept	Regulatory Bodies of India

	SLO-2	*Quality Statements*	*Juran Trilogy*	*Scatter diagram*	*Total Productive Maintenance*	*Medical Council of India*
S-7	**SLO-1**	*Strategic Planning*	*PDSA Cycle*	*Stratification*	*Improvement Needs*	*Pharmacy Council Of India*
	SLO-2	*Strategic Planning*	*PDSA Cycle*	*Stratification*	*Improvement Needs*	*Pharmacy Council Of India*
S-8	**SLO-1**	*Deming Philosophy*	*Kaizen*	*Six sigma*	*FMEA*	*Indian Nursing Council*
	SLO-2	*Deming Philosophy*	*Kaizen*	*Six sigma*	*FMEA*	*Indian Nursing Council*
S-9	**SLO-1**	*Barriers to TQM Implementation*	*5S*	*Six sigma*	*Stages of FMEA*	*Dental Council of India*
	SLO-2	*Barriers to TQM Implementation*	*5S*	*Six sigma*	*Stages of FMEA*	*Homeopathy Central Council*

Learning Resources	1. *Rose J.E, Total Quality Management, Kogan Page Ltd., 1993* 2. *Cesar A. Cacere, Albert Zana,The Practise of clinical Engineering, Academic Press,1997* 3. *Greg Bounds, Beyond Total Quality Management-Toward the emerging paradigm, McGraw Hill, 2013*	4. *Joseph J.Carr, Elements of Electronics Instrumentation and Measurement, 2nd ed., Pearson Education, 2003* 5. *Jerrold T. Bushberg, John M. Boone, The essential physics of medical imaging, 3rd ed., Lippincott Williams & Wilkins, 2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18ECO126T	Course Name	Sports Biomechanics	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE267J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the fundamental muscle action and locomotion in biomechanical point of view			
CLR-2 :	Get an idea about the movement patterns and causes of movements			
CLR-3 :	Understand the qualitative and quantitative analysis of sports movements			
CLR-4 :	Acquire an idea about the basic concept of jumping & aerial movement and throwing & hitting			
CLR-5 :	Get an idea about the injury prevention, rehabilitation and special Olympic sports			
CLR-6 :	Get an overall idea about the applications of biomechanics in sports			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the Interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu
CLO-1 :	Illustrate the muscle action in sport and locomotion	1	80	70	M												L		
CLO-2 :	Analyze the movement patterns and its causes	1,2	80	70	M												M		
CLO-3 :	Describe the Qualitative and Quantitative analysis of sports movements	2	80	70	M												M		
CLO-4 :	Analyze the movement of action such as jumping, throwing, hitting and aerial movement	2	80	70			L										L	L	L
CLO-5 :	Identify the injury scenario and special Olympic sports	2	80	70													L	L	L
CLO-6 :	Outline the major concepts in sports biomechanics																		

Duration (hour)		Muscle Action in Sport and Exercise and locomotion- Biomechanical view	Movement patterns and its causes	Qualitative and Quantitative analysis of sports movements	Jumping and Aerial Movement, Throwing and Hitting	Injury Prevention, Rehabilitation and Special Olympic Sports
		9	9	9	9	9
S-1	SLO-1	Introduction to Biomechanics	Introduction to Movement patterns	Introduction to Analysis of Sport Movements	Introduction to Aerial movement	Mechanisms of Musculoskeletal Injury
	SLO-2	Applications of Biomechanics	Defining human movements	A structured analysis framework	Types of Aerial Movement - Rotation during flight, Motion of the mass centre	Musculoskeletal Loading During Landing
S-2	SLO-1	Neural Contributions to Changes in Muscle Strength	Fundamental movements-Walking, Running	Preparation stage	Types of Aerial Movement : Somersaulting, Twisting,	Sport-Related Spinal Injuries and their Prevention
	SLO-2	Mechanical Properties and Performance in Skeletal Muscles	Fundamental movements-Throwing, Jumping	Observation stage	Control of aerial movement	Sport-Related Spinal Injuries and their Prevention
S-3	SLO-1	Muscle-Tendon Architecture	qualitative and quantitative movement	Evaluation and diagnosis stage	Introduction : High Jump	Impact Propagation and its Effects on the Human Body
	SLO-2	Athletic Performance	Comparison of qualitative and quantitative movement analysis	Intervention stage – providing appropriate feedback	Techniques of Jumping - Skating, Springboard and Platform Diving	Impact Propagation and its Effects on the Human Body
S-4	SLO-1	Eccentric Muscle Action in Sport and Exercise	Movement patterns-geometry of motion	Identifying critical features of a movement	Determinants of Successful Ski-Jumping Performance	Neuromechanics of the Initial Phase of Eccentric Contraction
	SLO-2	Stretch–Shortening Cycle of Muscle Function	Fundamentals of movement	Identifying critical features of a movement	Determinants of Successful Ski-Jumping Performance	Induced Muscle Injury

S-5	SLO-1	*Biomechanical Foundations of Strength*	*Linear motion and the centre of mass*	*The use of videography in recording sports movements*	*Principles of Throwing*	*Manual Wheelchair Propulsion*
	SLO-2	*Power Training*	*The geometry of angular motion and the coordination of joint rotations*	*The use of videography in recording sports movements*	*The Flight of Sports Projectiles*	
S-6	SLO-1	*Factors Affecting Preferred Rates of Movement in Cyclic Activities*	*Forces in sport*	*Recording the movement*	*Javelin Throwing: an Approach to Performance Development*	*Sports after Amputation*
	SLO-2	*The Dynamics of Running*	*Combinations of forces on the sports performer*	*Experimental procedures -Two dimensional videography*		
S-7	SLO-1	*Resistive Forces in Swimming*	*Momentum and the laws of linear motion*	*Experimental procedures -Three dimensional videography*	*Shot Putting*	*Biomechanics of Dance*
	SLO-2	*Propulsive Forces in Swimming*	*Force–time graphs as movement patterns*	*Data processing*	*Hammer Throwing: Problems and Prospects*	
S-8	SLO-1	*Performance-Determining Factors in Speed Skating*	*Determination of the centre of mass of the human body*	*Projectile motion*	*Hammer Throwing: Problems and Prospects*	*Biomechanics of Martial arts*
	SLO-2	*Cross-Country Skiing: Technique*	*Fundamentals of angular kinetics and Generation and control of angular momentum*	*Linear velocities and accelerations caused by rotation*	*Hitting*	
S-9	SLO-1	*Cross-Country Skiing: Equipment*	*Measurement of force*	*Rotation in three-dimensional space*	*Kicking*	*Biomechancis of YOGA*
	SLO-2	*Factors Affecting Performance*	*Measurement of pressure*	*Rotation in three-dimensional space*	*Simple concept problems*	

Learning Resources	1. *Susan J Hall, "Basic Biomechanics", McGraw-Hill Higher Education, 7th edition, 2014* 2. *Vladimir M. Zatsiorsky, Biomechanics in Sports: Performance Enhancement and Injury Prevention, 1st ed., Blackwell Science Ltd, 2000*	3. *Jules Mitchell,"Yoga Biomechanics", 1 edition , Handspring Publishing Limited ,2018* 4. *Roger Bartlett, Introduction to Sports Biomechanics: Analysing Human Movement Patterns, 2nd ed., Routledge, 2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
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Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECO131J	Course Name	VIRTUAL INSTRUMENTATION	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Study the concepts of Virtual instrumentation and to learn the programming concepts in VI.			
CLR-2 :	Study about the various real time data acquisition methods.			
CLR-3 :	Study about the various Instrument Interfacing concepts.			
CLR-4 :	To study the programming techniques for various control techniques using VI software			
CLR-5 :	To study various analysis tools for Process control applications.			
CLR-6 :	To study various real time measurement systems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO 1: Automatic control for continous & discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	An ability to understand the purpose of virtual instrumentation and understand the construction of VI	1,2	80	70	H												H		
CLO-2 :	An ability to understand and apply various data acquisition methods.	2	85	75	H												H	H	
CLO-3 :	An ability to understand and implement the available interfacing instruments	2	75	70	H	H	H	H	H								H	H	H
CLO-4 :	An ability to understand and implement various control techniques using VI software	2,3	85	80	H	H	H	H	H								H		H
CLO-5 :	An ability to understand and develop a program foran engineering application.	2,3	85	75	H	H	H	H	H				H	H	H	H	H	H	
CLO-6 :	An ability to understand and implement various measurement systems	2,3	80	70	H	H	H	H	H				H	H	H	H	H	H	

Duration (hour)		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
		12	12	12	12	12
S-1	SLO-1	Historical perspective, Need of VI, Advantages of VI, Virtual Instruments versus Traditional Instruments	A/D Converters, Organization of the DAQ VI system -	Introduction to PC Buses	Introduction to Non continuous controllers in LabVIEW	PC based digital storage oscilloscope
	SLO-2	Review of software in Virtual Instrumentation ,Software environment Architecture of VI, Introduction to the block diagram and Front panel Pallets	D/A Converters, Types of D/A	Local Buses-ISA, PCI,	Introduction to continuous controllers in LabVIEW	Sensor Technology
S-2	SLO-1	Creating and saving a VI, Front Panel Tool Bar, Block diagram Tool Bar, Palettes	plug-in Analog Input/output cards - Digital Input and Output Cards,	RS232, RS422	Design of ON/OFF controller	Applications of sensor Technology
	SLO-2	Creating sub VI, Creating an ICON, Building a connector pane, Displaying VI'S, Placing and Saving Sub VI'S on block diagram, Example of full adder circuit using half adder circuit	Organization of the DAQ VI system -	RS485	Proportional controller for a mathematically described processes using VI software	Signal processing Techniques
S-3	SLO-1	***Lab-1:*** Front Panel controls and Indicator	***Lab-12:*** Measurement of diode I-V characteristics using LabVIEW	***Lab-17:*** Load cell Data acquisition using RS232	***Lab-22:*** On-off temperature controller using LabVIEW	***Lab-28:*** Design of DSO
	SLO-2	***Lab-2:*** Verification of Arithmetic Operations				
S-4	SLO-1	***Lab-3:*** Verification of Half Adder	***Lab-13:*** Temperature measurement using LabVIEW and DAQ hardware.		***Lab-23:*** Continuous Control of temperature using LabVIEW	***Lab-29:*** Analysis of different signal Filters using LabVIEW
	SLO-2	***Lab-4:*** Verification of Full adder.				
S-5	SLO-1	Loops-For Loop,	Opto Isolation need	Interface Buses-USB,PXI	Modeling of level process	Spectrum Analyzer

	SLO-2	*While Loop*	*Performing analog input and analog output*	*VXI,*	*Basic control of level process in LabVIEW*	*Waveform Generator*
S-6	SLO-1	*Arrays,*	*Scanning multiple analog channels*	*SCXI*	*Modeling of Reactor Processes*	*Data visualization from multiple locations*
	SLO-2	*Clusters, plotting data*	*Issues involved in selection of Data acquisition cards*	*PCMCIA*	*Basic control of Reactor process in LabVIEW*	*Distributed monitoring and control*
S-7	SLO-1	***Lab-5:** Program to find Addition of First n natural numbers using for loop*	***Lab-14:** Flow measurement in water using LabVEW and DAQ hardware*	***Lab-18:** DC motor control using VXI*	***Lab-24:** On-off Level controller using LabVIEW*	***Lab-30:** Real time spectrum analysis using LabVIEW*
	SLO-2	***Lab-6:** Program to find Addition of First n odd numbers using while loop.*				
S-8	SLO-1	***Lab-7:** Implementation of Array functions.*		***Lab-19:** GPIB with VISA functions*	***Lab-25:** Continuous Control of pressure controller using LabVIEW*	***Lab-31:** Arbitratory Waveform Generator using LabVIEW*
	SLO-2	***Lab-8:** Calculation of BMI using cluster*				
S-9	SLO-1	*Charts*	*Data acquisition modules with serial communication*	*Instrumentation Buses - Modbus and GPIB*	*Case studies on development of HMI in VI*	*Vision and Motion Control*
	SLO-2	*Graphs*	*Design of digital voltmeters with transducer input*	*Networked busses – ISO/OSI*	*Case studies on development of HMI in VI*	Examples on Integrating Measurement with vision and motion
S-10	SLO-1	*Case and Sequence Structures*	*Timers and Counters*	*Reference model,*	*Case studies on development of SCADA in VI*	NI Motion control
	SLO-2	*Formula nodes, String and File Input/Output.*	*Timers and Counters*	*Ethernet and TCP / IP Protocols*	*Case studies on development of SCADA in VI*	Speed control system
S-11	SLO-1	***Lab-9:** Monitoring of temperature using Charts and Graphs*	***Lab-15:** Design of digital voltmeters with transducer input using LabVIEW*	***Lab-20:** Online temperature control using LabVIEW using TCP/IP*	***Lab-26:** On-off pressure controller using LabVIEW*	***Lab-32:** Minor Project*
	SLO-2	***Lab-10:** Program for implementing Seven segment display*				
S-12	SLO-1	***Lab-11:** Program to perform Traffic light control*	***Lab-16:** Pressure measurement using LabVEW and DAQ hardware DAQ.*	***Lab-21:** Online temperature control using Web publishing tool*	***Lab-27:** Continuous Control of pressure controller using LabVIEW*	
	SLO-2					

Learning Resources	1. *Nadovich, C., Synthetic Instruments Concepts and Applications, Elsevier, 2005* 2. *Bitter, R., Mohiuddin, T. and Nawrocki, M., Labview Advanced Programming Techniques, 2nd ed., CRC Press, 2007* 3. *Gupta, S. and Gupta, J. P., PC Interfacing for Data Acquisition and Process Control", 2nd ed., Instrument Society of America, 1994*	4. *Jamal, R., Picklik, H., Labview – Applications and Solutions, National Instruments Release.* 5. *Johnson, G., Labview Graphical programming, McGraw-Hill, 1997* 6. *Wells, L.K., Travis, J., Labview for Everyone, Prentice Hall, 1997* 7. *Buchanan, W., Computer Busses, CRC Press, 2000*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr. K. A. Sunitha, SRMIST*
2. V. Venkateswaran, Instrumentation Consultant, vvenkat99@gmail.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Mrs. A. Brindha, SRMIST*

Course Code	18ECO132T	Course Name	ANALYTICAL INSTRUMENTATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the principle and theory of analytical instruments
CLR-2 :	Understand the quantitative analysis of dissolved components
CLR-3 :	Study the concept of separation science and its applications
CLR-4 :	Study the various spectroscopic techniques and its instrumentation
CLR-5 :	Identify and solve engineering problems associated with Radiation Techniques
CLR-6 :	Understand the working of Analytical Instrument and their importance in industries

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO 1: Automatic control for continous & discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	Apply the principles and theory of instrumental analysis	1,2	80	70	H	H	L	L	H	H	H						H	H	L
CLO-2 :	Apply the principles of various chemical analysis instruments in industries	1,2	85	75	H	H	L	L	H	H							H	H	L
CLO-3 :	Analyze and understand the operation of various radio chemical methods of analysis	1,2	75	70	H	H	L	L	H	H							H	H	L
CLO-4 :	To analyze and understand the operation of instruments based on optical properties	1,2	85	80	H	H	L	L	H	H							H	H	L
CLO-5 :	To identify and solve engineering problems associated with Radiation Techniques	1,2	85	75	H	H	L	L	H	H							H	H	L
CLO-6 :	To understand the working of analytical Instruments in industries	1,2	80	70	H	H	L	L	H	H							H	H	L

Duration (hour)		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
		9	9	9	9	9
S-1	SLO-1	Introduction to Chemical instrumental analysis	Dissolved oxygen analyzer, Importance of measuring dissolved oxygen in Industry, Principle working	Chromatography, Importance, Basic working of Chromatography	Spectral methods of analysis- Properties or parameters of electromagnetic radiation	NMR spectrometers ,Importance and basic working of NMR Spectroscopy
	SLO-2	Spectral method of analysis	Working of Dissolved oxygen analyzer	Gas chromatography Instrumentation	Electromagnetic spectrum Types of spectrometers	Magnetic assembly, Probe unit, Instrument stabilization
S-2	SLO-1	Electro analytical and seperative methods	sodium analyzer, Importance of measuring sodium in Industry, Principle working	Basic parts of a gas chromatography	Beer's law UV-visible spectrophotometers Transmittance and absorbance	Types of NMR spectrometer, Minimal type
	SLO-2	Instrumental methods of analysis-basic components and their classification	Working of sodium analyzer	Carrier gas supply Sample injection system	Beer's law Application of beer's law	Multipurpose NMR,Wideline
S-3	SLO-1	Sampling systems	Silica analyzer, Importance of measuring Silica in Industry, Principle working	Chromatographic column, Selection of column	Derivations of beer's law	Applications of NMR Spectrometer
	SLO-2	Importance of Sampling system in chemical Industries and Safety aspects	Working of Silica Analyzer	Thermal compartment, Detection system, Recording system	Single beam and double beam instruments	Mass Spectrometers, Basic working and Importance
S-4	SLO-1	PH Measurement, Principle of PH measurement & Importance of PH measurement in Industries	Moisture measurement Importance of Moisture measurement	Liquid chromatography-Principles, types and applications	IR spectrophotometers Instruments of IR	Components of Mass Spectrometers
	SLO-2	Types of Electrodes, Reference Electrodes and types	Types of Moisture measurement	High pressure liquid chromatography	Types of IR Components required for three types of IR	Types of Mass spectrometers Magnetic Sector analyzer, Double focusing spectrometers
S-5	SLO-1	Secondary Electrodes and Types	Oxygen analyzer Methods of oxygen analyzers and importance	Instrumentation or basic component of HPLC	Instruments of dispersive instrument , IR Radiation Sources and types	Time of flight analyzers, Quadrupole Mass analyzers

	SLO-2	*Indicator electrodes*	*Paramagnetic oxygen analyzer* *Electro analytical method*	*Solvent reservoir and its treatment system*	*Importance of Monochromators and types of Monochromators*	*Application of mass spectrophotometers*
S-6	**SLO-1**	*pH meters* *direct reading type pH meter* *null detector type pH meter*	*CO monitor,Importance of measuring CO*	*Pumping system, Types of working systems and Importance*	*Samples And Sample Cells* *detectors*	*nuclear radiation detectors, importance of measurement*
	SLO-2	*ion selective electrodes* *Types of ion selective electrodes* *Glass membrane electrodes* *Liquid membrane electrodes* *Solid membrane Electrodes*	*Types of CO monitor*	*Pulse dampers*	*FTIR spectrometers, Main components* *Advantages, disadvantages*	*GM counter*
S-7	**SLO-1**	*Biosensors* *Features of Biosensor* *Block diagram of bio sensor*	*NO2 analyzer, Importance of NO_2 measurement*	*Sample injection system and types*	*Types of sources* *Selection factors*	*Working setup, advantages of GM Counter*
	SLO-2	*Applications of Biosensors in industries*	*Types of NO_2 measurement*	*Liquid chromatographic column working , Types of Column thermostats*	*Types of detectors* *Selection factors*	*proportional counter, Basic Principle*
S-8	**SLO-1**	*conductivity meters ,Importance in Chemical Industries*	*H_2S analyzer, Importance of H_2 S Measurement*	*Detection system types*	*atomic absorption spectrophotometer* *instruments for atomic absorption spectroscopy*	*Working setup, advantages of GM Counter*
	SLO-2	*Types of Conductivity meters*	*Types of H_2S measurement*	*Types of Recording system*	*radiation source* *chopper*	*solid state detectors, Basic Principle*
S-9	**SLO-1**	*Air pollution Monitoring Instruments*	*Dust and smoke measurement-* *dust measurement and Importance* *Types of dust measurement*	*Application of HPLC, Advantages of HPLC over gas chromatography*	*production of atomic vapor by flame, Parts by flame photometer* *Emission system*	*Working setup, advantages of Solid state detectors*
	SLO-2	*Estimation of Air pollution*	*Thermal analyzer , Importance of Thermal analyzers, Types of Thermal analyzer*	*Detectors types, Factors Influencing the Selection of Detectors*	*Monochromators* *And types, Types of Detectors and recording systems and their selection criteria*	*scintillation counter, Basic principle*

Learning Resources	1. *Khandpur. R.S, "Handbook of Analytical Instruments", Tata McGraw Hill publishing Co. Ltd., 2006* 2. *Bella. G, Liptak, "Process Measurement and analysis"., CRC press LLC.,2003.* 3. *Francis Rousseau and Annick Rouesssac "Chemical analysis Modern Instrumentation Methods and Techniques", John wiley & sons Ltd.2007.*	4. *James W.Robinson,"Undergraduate Instrumental Analysis", Marcel Dekker., 2005.* 5. *Dwayne Heard, "Analytical Techniques for atmospheric measurement", Blackwell Publishing, 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*Dr. K. A. Sunitha, SRMIST*
2. V. Venkateswaran, Instrumentation Consultant, vvenkat99@gmail.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*Mrs. A. Brindha, SRMIST*

Course Code	18ECO133T	Course Name	LOGIC AND DISTRIBUTED CONTROL SYSTEM	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand basic components of PLC
CLR-2 :	Understand the use of timers and counters in process automation
CLR-3 :	Understand DCS architecture
CLR-4 :	Understand operator and engineering interface in DCS
CLR-5 :	Understand HART signal standard and Field bus
CLR-6 :	Understand Field bus signal standard.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO 1: Automatic control for continous & discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	Select PLC based on I/O's	2,3	80	80	H	M	L	-	-	-	-	-	M	-	M	L	M		M
CLO-2 :	Apply timers and counters in process automation	1,2	80	80	H	H	H	H	H	-	L	-	H	M	L	L	H	H	H
CLO-3 :	Select LCU based on application	1	80	80	H	M	-	-	-	-	-	-	L	-	-	L	M	L	M
CLO-4 :	Analyse data's in Operator displays	3	80	80	H	H	-	H	-	-	-	-	H	M	-	L	H	L	M
CLO-5 :	Interpret industrial data communication modes	3	80	80	H	-	-	-	-	-	-	-	-	L	-	L	H	-	L
CLO-6 :	Gain knowledge on field bus	3	80	80	H	L	-	-	-	-	-	-	-	-	-	L	H	-	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Programmable logic controllers	PLC Programming Languages	Evolution of DCS	Operator Interfaces Requirements	Introduction to HART
	SLO-2	PLC vs Computer	Ladder Diagram	Hybrid System Architecture	Process Monitoring	Evolution of Signal standard
S-2	SLO-1	Parts of a PLC	Functional block	Central Computer system Architecture	Process Control	HART Networks: Point-to-Point
	SLO-2	Architecture	Sequential Function Chart	DCS Architecture	Process Diagnostics	Multi-drop
S-3	SLO-1	PLC size and Application.	Instruction List	Comparison of Architecture	Process Record Keeping	Split range control valve
	SLO-2	Fixed and Modular I/O	Structured Text	Local Control Unit Architecture	Low Level Operator Interface	HART Field Controller Implementation
S-4	SLO-1	Discrete Input Modules	Wiring Diagram	Architectural Parameters	High Level Operator Interface	Hart Commends: Universal
	SLO-2	Discrete Output Modules	Ladder logic Program	Comparison Of LCU Architecture	Hardware Elements In The Operator Interface	Common Practice
S-5	SLO-1	Analog Input Modules	On-Delay Timer Instruction	LCU Language Requirements	Operator Input And Output Devices	Device Specific
	SLO-2	Analog Output Modules	Off-Delay Timer Instruction	Function Blocks	Operator Display Hierarchy	Wireless Hart
S-6	SLO-1	Special I/O Modules	Retentive Timer	Function Block Libraries	Plant-Level Display	Field Bus Basics
	SLO-2	High Speed Counter Module	Cascading Timer	Problem-Oriented Language	Area- Level Display	Field Bus Architecture
S-7	SLO-1	Power Supplies	Up-Counter	LCU Process Interfacing Issues	Group- Level Display	Field Bus Standard
	SLO-2	Isolators	Down-Counter	Security Requirements	Loop- Level Display	Field Bus Topology
S-8	SLO-1	Input/output Devices: Switches	Cascading Counters	Security Design Approach	Engineering Interface Requirements	H1 Field Bus
	SLO-2	sensors	Combining Counter And Timer Functions	On-Line Diagnostics	Requirement For Operator Interface Configuration	H2 Field Bus
S-9	SLO-1	Relays	Math Operation	Redundant Controller Design	Low Level Engineering Interface,	Interoperability
	SLO-2	Solenoid valve	Program	One-On-One, One-On-Many Redundancy	High Level Engineering Interfaces	Interchangeability

Learning Resources	1. Frank D. Petruzella, Programmable Logic Controller, Tata McGraw Hill Fifth Edition, 2017 2. Bolton. W, Programmable Logic Controllers, 6th Edition, Elsevier Newnes, Sixth Edition 2016. 3. Krishna Kant, Computer Based Industrial Control, Second edition, Prentice Hall of India, New Delhi,2015	4. Bowten, R HART Application Guide, HART Communication foundation, 2015. 5. Berge, J, Field Busses for process control: Engineering, operation, maintenance, ISA press,2015

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Code	18ECO134T	Course Name	SENSORS AND TRANSDUCERS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Instrumentation Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Gain knowledge on classification, and characteristics of transducers
CLR-2 :	Acquire the knowledge of different types of inductive and capacitive sensors
CLR-3 :	Acquire the knowledge of different types of thermal and radiation sensors
CLR-4 :	Acquire the knowledge of different types of magnetic sensors
CLR-5 :	Acquire the knowledgeof different types of sensors measuring non-Electrical quantity
CLR-6 :	Locate the Applications of sensors in industries and home appliances

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	To demonstrate the various types of basic sensors.	2,3	80	80
CLO-2 :	Understand the inductive and capacitive sensors which are used for measuring various parameters.	1,2	80	80
CLO-3 :	Understand the thermal and radiation sensors	1	80	80
CLO-4 :	Have an adequate knowledge on the various magnetic sensors	3	80	80
CLO-5 :	To demonstrate the various types of basic sensors measuring non electrical quantity	3	80	80
CLO-6 :	Select the right transducer for the given application	3	80	80

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO 1: Automatic control for continuous& discrete systems	14 PSO-2: Utilize PLC & DCS for control of systems	15 PSO-3: Effective management skills
CLO-1 :	H	-	H	-	-	H	H	H	-	-	-	H	H	-	-
CLO-2 :	H	-	-	H	-	H	-	-	-	-	-	H	-	H	-
CLO-3 :	-	-	-	-	-	H	-	-	H	H	-	-	H	-	-
CLO-4 :	-	H	H	-	-	-	-	-	-	-	-	-	-	H	-
CLO-5 :	-	-	H	-	H	-	-	-	-	-	-	H	-	-	H
CLO-6 :	H	-	H	-	-	H	H	H	-	-	-	H	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to sensors/ transducers, Principles	Introduction to Inductive sensor	Thermal sensors: Introduction	Magnetic sensors: Introduction	Measurement of Non-Electrical quantity: Introduction
	SLO-2	Classification based on different criteria	Sensitivity and linearity of the sensor	Thermal Expansion type.	Villari effect	Flow Measurement – Introduction.
S-2	SLO-1	Characteristics of measurement systems	Transformer type transducer	Acoustics temperature sensors.	Wiedmann effect	Ultrasonic Flow Meters.
	SLO-2	Static characteristics Accuracy, Precision, Resolution, Sensitivity	Electromagnetic transducer	Thermo-emf sensor.	Hall effect	Hot Wire Anemometers.
S-3	SLO-1	Dynamic characteristics.	Magnetosrtictive transducer	Materials for thermos-emf sensors.	Construction,	Electromagnetic Flow meters.
	SLO-2	Environmental Parameters	Materials used in inductive sensor	Thermocouple construction	performance characteristics,	Principle and types.
S-4	SLO-1	Characterization and its type	Mutual Inductance change type	Types.	and its Application	Measurement of Displacement.
	SLO-2	Electrical characterization.	LVDT: Construction.	Thermo-sensors using semiconductor device	Introduction to smart sensors	Introduction and types.
S-5	SLO-1	Mechanical Characterization.	Material, input output relationship,	Pyroelectric thermal sensors	Film sensors: Introduction	Measurement of Velocity/ Speed.
	SLO-2	Thermal Characterization	Synchros-Construction	Introduction	Thick film sensors	Introduction and types.
S-6	SLO-1	Optical Characterization.	Capacitive sensor: Introduction	characteristics	Microelectromechanical systems	Measurement of Liquid Level.
	SLO-2	Errors and its classification.	Parallel plate capacitive sensor	Application	Micromachining.	Introduction and types.
S-7	SLO-1	Selection of transducers.	Variable thickness dielectric capacitive sensor	Radiation sensors.	Nano sensors	Measurement of Pressure.

	SLO-2	*Introduction to mechanical sensors*	*Electrostatic transducer*	*Introduction*	*Applications: Industrial weighing systems: Link–lever mechanism.*	*Introduction and types.*
S-8	**SLO-1**	*Resistive potentiometer and types*	*Piezoelectric elements*	*Characteristics*	*Load cells – pneumatic, elastic and their mounting.*	*Measurement of Vibration.*
	SLO-2	*Strain gauge: Theory, type, design consideration, sensitivity.*	*Ultrasonic Sensors*	*Geiger counters*	*different designs of weighing systems.*	*Introduction and types.*
S-9	**SLO-1**	*Resistive transducer: RTD, materials used in RTD*	*Calculation of sensitivity.*	*Scintillation detectors*	*conveyors type.*	*Application of sensors in industries*
	SLO-2	*Thermistor: thermistor material, shape*	*Capacitor microphone, response characteristics*	*Application on radiation sensors*	*weighfeeder type.*	*Application of sensors in home appliances*

Learning Resources	1. *Patranabis, D., "Sensors and Transducers", 2nd Edition, Prentice Hall India Pvt. Ltd, 2010.* 2. *Doeblin, E.O., "Measurement Systems: Applications and Design", 6thEdition, Tata McGraw-Hill Book Co., 2011.* 3. *Bentley, J. P., "Principles of Measurement Systems", 4th Edition, Addison Wesley Longman Ltd., UK, 2004.*	4. *Murthy, D.V.S., "Transducers and Instrumentation", Prentice Hall of India Pvt. Ltd., New Delhi, 2010.* 5. *Neubert H.K.P., "Instrument Transducers – An Introduction to their performance and Design", Oxford University Press, Cambridge, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*Mrs. K. Vibha, SRMIST*
2. V. Venkateswaran, Instrumentation Consultant, vvenkat99@gmail.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*Dr. G. Joselin Retna Kumar, SRMIST*

Course Code	18ECO135T	Course Name	FUNDAMENTALS OF MEMS	Course Category	O	*Open Elective*	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Communication Engineering*	**Data Book / Codes/Standards**	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the importance of micro system technology*
CLR-2 :	*Learn the operating principle of various micro sensors and actuators*
CLR-3 :	*Impart the applications of various micro fabrication techniques*
CLR-4 :	*Understand the differences and need for microfabrication*
CLR-5 :	*Operate MEMS design tools to design simple micro devices*
CLR-6 :	*Understand recent developments and challenges in MEMS*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	**Learning**			**Program Learning Outcomes (PLO)**															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO 1: Automatic control for continuous& discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	*Appreciate the fundamental concepts in MEMS technology*	*2,3*	*80%*	*80%*	*H*	-	-	-	-	*H*	-	-	-	-	-	*H*	*H*	-	*H*
CLO-2 :	*Understand the fabrication and machining techniques of MEMS devices*	*1,2*	*80%*	*80%*	*H*	-	-	-	-	*H*	-	-	-	-	-	*H*	-	-	*H*
CLO-3 :	*Familiarize with the concepts of packaging of MEMS devices*	*1*	*80%*	*80%*	*H*	-	-	*H*	-	*H*	-	-	-	-	-	*H*	*H*	-	*H*
CLO-4 :	*Appreciate the significance of micro fabrication processes*	*3*	*80%*	*80%*	*H*	-	-	*H*	-	-	-	-	-	-	-	*H*	-	-	*H*
CLO-5 :	*Design and Simulate simple structures using MEMS software*	*3*	*80%*	*80%*	*H*	-	*H*	*H*	*H*	-	-	*H*	*H*	-	-	*H*	*H*	-	*H*
CLO-6 :	*Analyze recent trends and developments in MEMS technology*	*3*	*80%*	*80%*	*H*	-	-	*H*	-	-	-	-	-	-	-	*H*	*H*	-	*H*

Duration (hour)		**Introduction**	**Fabrication overview**	**Micromachining**	**Bonding & Sealing**	**Recent trends**
		9	**9**	**9**	**9**	**9**
S-1	**SLO-1**	*Introduction to MEMS and Brief recap of Macro devices*	*Introduction to Micro fabrication process*	*Introduction of micro machining(MMC) process*	*Introduction to MEMS packaging*	*Introduction to design tools and simulation*
	SLO-2	*Microelectronics and Micro systems*	*Significance of each technique*	*Significance of MMC*	*Challenges in packaging*	*FEM analysis*
S-2	**SLO-1**	*Scaling laws in geometry*	*Process Description of Photolithography*	*Bulk MMC process – merits and demerits*	*Different levels of Packaging*	*Design of a silicon die for a micro pressure sensor*
	SLO-2	*Silicon as ideal material and as substrate*	*Implementation of Photolithography*	*Sequence of steps*	*Die, device and system level*	*Simulation in software*
S-3	**SLO-1**	*Si wafer production*	*Process Description of CVD*	*Significance of Isotropic etching*	*Differences in IC packaging technology And MEMS packaging*	*Application of MEMS in automotive industry*
	SLO-2	*Cz process*	*Implementation, merits and demerits of CVD*	*Anisotropic etching*		*Airbag deployment*
S-4	**SLO-1**	*Sequential steps in wafer processing*	*Process Description of PVD*	*Surface MMC process*	*Die Preparation*	*Optical MEMS Application*
	SLO-2		*Implementation, merits and demerits of PVD*	*Sequence of steps*	*Plastic encapsulation and its significance*	*Micro mirrors*
S-5	**SLO-1**	*Chemical and mechanical properties of Si and compounds*	*Process Description, implementation of Ion implantation*	*Challenges in surface MMC*	*Types of wire bonding Thermo compression type*	*Micro fluidics Application*
	SLO-2	*Chemical and mechanical properties of Polymers, Quartz and GaAs*	*Oxidation process*	*Interfacial & Residual stresses*	*Thermo sonic, Ultra sonic type*	*Lab on chip module*
S-6	**SLO-1**	*Chemical, Biomedical type Micro sensors*	*Diffusion process*	*LIGA process- description merits and demerits*	*Types of surface bonding – Adhesive*	*IR and Gas sensing*

	SLO-2	*Piezoelectric type of Micro sensors*	*Wet etching methods*	*Implementation*	*soldering, SOI type of bonding*	*Thermal sensors*
S-7	**SLO-1**	*Thermal, SMA, Piezoelectric actuators*	*Properties of etchants*	*Process Design-block diagram and description*	*Anodic bonding and lift off process*	*Micro power generation*
	SLO-2	*Electro static type Micro Actuators*	*Dry etching methods*	*Electro-mechanical design, Thermo-electric design*	*Precautions to be taken*	*Micro TEG*
S-8	**SLO-1**	*Micro devices- operation of Micro gears and micromotors*	*Production of plasma*	*CAD- block diagram description and implementation*	*Types of sealing- Micro shells, Hermetic sealing*	*Chemical sensors*
	SLO-2	*Micro devices –operation of Micro valves and pumps*	*Etch stop methods*		*Micro 'O' rings,Reactive seal*	*Micro humidity sensors*
S-9	**SLO-1**	*Case study*	*Case study*	*Case study*	*Selection of packaging materials*	*Micro pressure sensors*
	SLO-2				*Material requirements*	*Paper MEMS*

Learning Resources	1. *Tai-Ran Hsu, "MEMS and MICROSYSTEMS", 22nd reprint edition, Wiley & sons, 2015* 2. *M. Madou, "Fundamentals of Micro fabrication", Taylor and Francis group, 2002*	3. *VardhanGardener,"Micro sensors and smart devices", John Wiley & Sons,2001* 4. *NPTEL link:* https://nptel.ac.in/downloads/112108092/

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. R.Bakiyalakshmi,SRMIST*

B. Tech in Electronics and Communication Engineering
(with Specialization in BioMedical Engineering)

2018 Regulations

Project Work, Seminar, Internship in Industry / Higher Technical Institutions (P)

Department of Electronics and Communication Engineering
SRM Institute of Science and Technology
SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECP109L / 18ECP110L	Course Name	PROJECT / SEMESTER INTERNSHIP	Course Category	P	*Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)*	L	T	P	C
							0	0	20	10

Pre-requisite Courses	*Nil*	Co-requisite Courses	Nil	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Communication Engineering*	**Data Book / Codes/Standards**		*As required for the project work*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To prepare the student to gain major design and or research experience as applicable to the profession*
CLR-2 :	*Apply knowledge and skills acquired through earlier course work in the chosen project*
CLR-3 :	*Make conversant with the codes, standards , application software and equipment*
CLR-4 :	*Carry out the projects within multiple design constraints*
CLR-5 :	*Incorporate multidisciplinary components*
CLR-6:	*Acquire the skills of comprehensive report writing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*
CLO-1 :	*Design a system / process or gain research insight into a defined problem as would be encountered in engineering practice taking into consideration its impact on global, economic, environmental and social context.*

Learning Assessment					
Continuous Learning Assessment	Assessment tool	Review I	Review II	Review III	Total
	Weightage	5%	20%	25%	50%
Final Evaluation	Assessment tool	Project Report	Viva Voce *		Total
	Weightage	20%	30%		50%

* Student has to be present for the viva voce for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'

Course Code	18ECP107L	Course Name	MINOR PROJECT	Course Category	P	Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)	L	T	P	C
							0	0	6	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	As required for the project work		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Prepare the student to formulate an engineering problem within the domain of the courses undergone
CLR-2 :	Seek solution to the problem by applying codes / standards/ software or carrying out experiments or through programming

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1 :	Identify a small part of major system or process, understand a problem associated with it and find solution or suggest a procedure leading to its solution.

Learning Assessment					
Continuous Learning Assessment	Assessment tool	Review I	Review II	Final Review *	Total
	Weightage	20%	30%	50%	100%

* Student has to be present for final review for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'

Course Code	18ECP102L / 18ECP105L	Course Name	Industrial Training I / II	Course Category	P	Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	As exposed to during the duration of training		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Provide an exposure to the students on the practical application of theoretical concepts in an industry or research institute

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1 :	Gain confidence to carry out supervisory, managerial, and design roles in an industrial context.

Learning Assessment			
Continuous Learning Assessment	Assessment tool	Final review	
	Weightage	Training Report	Presentation *
		75%	25%

* Student has to be present for the presentation for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'

Course Code	18ECP108L	Course Name	Internship	Course Category	P	Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)	L	T	P	C
							0	0	6	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	As exposed to during the duration of internship		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Provide an exposure to the students on the practical application of theoretical concepts in an industry or research institute and also to gain hands on experience in the context of design, production and maintenance

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1 :	Gain confidence to carry out supervisory, managerial, and design roles in an industrial context or research environment

Learning Assessment			
Continuous Learning Assessment	Assessment tool	Final review	
	Weightage	Training Report	Presentation*
		75%	25%

* Student has to be present for the presentation for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'

Course Code	18ECP103L / 18ECP106L	Course Name	Seminar I / II	Course Category	P	Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	As applicable		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Identify an area of interest within the program or a related one (multidisciplinary), carry out a literature survey on it, gain understanding and present the same before an audience.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1 :	Carry out a self-study of an area of interest and communicate the same to others with clarity.

Learning Assessment			
Continuous Learning Assessment	Assessment tool	Presentation	
	Weightage	Presentation material	Presentation skills / ability to answer questions / understanding of the topic*
		60%	40%

* Student has to be present for the presentation for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'